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CANTOR LECTURES

ON

CLIMATE IN ITS RELATION TO HEALTH.

BY

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CLIMATE IN ITS RELATION TO HEALTH.

BY G. V. POORE, M.D.

LECTURE I.—DELIVERED JANUARY 12, 1885.

INTRODUCTION.—METEOROLOGY IN RELATION TO CLIMATE.

It seems necessary, to begin with, to offer some definition of the word "Climate;" and yet, as we all know pretty well what we mean by climate, it is perhaps hardly advisable that I should fetter your ideas by any hard-and-fast definition, and I am sure that it is not advisable that I should fetter myself, for I intend to treat of climate in the freest manner possible, and I must by anticipation ask your indulgence for many divergencies from the conventional ideas of "climate." The definitions given by Dr. Hermann Weber, in the second volume of Von Ziemssen's "Handbuch der allgemeinen Therapie," is probably wide enough for all purposes, and although I do not promise to be bound even by it, I offer it as a sort of foundation upon which to build my remarks. Dr. Weber says, "By climate we mean the sum of those influences which act upon the life of organic beings through the air, soil, or water of a district."

The earth is surrounded by a gaseous envelope, having a depth, it is supposed, of some forty miles. Crawling at the bottom of this ocean of air is man, who may be likened to a crustacean crawling at the bottom of the sea. Some animals there are—birds, insects, and the like—which are able to live in the higher, purer regions of the atmosphere. Man crawls along the bottom, and lives in the lowest strata, which are often rendered cloudy by the dust of various kinds, which is raised by himself and his teeming fellows. Life without the atmosphere is inconceivable. Not only does it minister to those chemical changes which are constantly going on in the body, and the cessation of which means death, but the pressure which the atmosphere exerts on our bodies (varying from twelve to fifteen pounds per square inch of surface, according to the elevation above sea level) is probably essential for the well-being of our bodies as at present constituted. Without the atmosphere, the evaporation of water and its re-condensation in the form of dew, rain, and snow would probably cease; and, finally, without the atmosphere, which is spread like a transparent curtain between us and the sun, not only would the sun's rays be perfectly insupportable, but the transitions of temperature would have a suddeness and severity to which it would be impossible to accommodate outselves.

GASEOUS CONSTITUENTS OF THE ATMOSPHERE.

The atmosphere is almost uniform in composition. In 100 volumes of air there are of—

Nitrogen	79·00 volumes.
Oxygen	20·96 ,,
Carbonic acid....	00·04 ,,
	100·00

Of these gases the oxygen is the most important. It is the great supporter of life, the gas that carries on the combustion of the human body, that maks the flame of life burn brightly, that calls forth the energy of the animal machine, and enables us to maintain our body temperature in all weathers.

Since we breathe some sixteen times in a minute, and inspire about a pint of air every time we draw our breath, it is evident that the amount of air we require per diem is prodigiously great, and that the purity of the air we breathe is a matter of prime importance.

Whence come the gases which form the chief constituents of the atmosphere? Of the source of origin of the nitrogen we know nothing. Of its uses we know nothing.

Its chemical action in the great function of respiration appears to be *nil*, and, although it constitutes nearly four-fifths of the total bulk of the air we breathe, its properties seem to be to a great extent negative. Even supposing that its main function be to diffuse and dilute the oxygen, we must be careful not to underrate such a function.

The main source of carbonic acid is the respiration of animals and other forms of combustion. The air we breathe returns from our lungs highly charged with carbonic acid and moisture—too impure to breathe a second time. Countless millions of animals, high and low in the scale, are engaged in fouling the atmosphere, and in pouring carbonic acid gas into it, and at the same time in using up the oxygen. If, then, every creeping thing that lives upon the globe is constantly using up oxygen and giving off carbonic acid, the question arises, how is the oxygen renewed, and how is the carbonic acid got rid of? The answer is that vegetable and animal life are complementary to each other, and that every green leaf of every waving forest tree, every blade of grass that clothes the sward, every green seaweed and river weed, is actively engaged in absorbing carbonic acid from the air or water, fixing the carbon, and returning the oxygen to the air for the benefit of animals. Thus carbonic acid is constantly being given off by one class of organisms (the animal), and greedily devoured by the other great class of organisms (the vegetable), while the oxygen given off by the vegetables is devoured by the animals.

If the renewal of the chief constituents of the air is thus provided for, it is still not at first obvious why it is that the air is almost uniform in composition. In some places, as in this great overgrown city, for example, animals are greatly in excess of vegetables, and we should expect to find that, in the air of London, there was great excess of carbonic acid. Excess there is, but not to the extent that we should have perhaps imagined.

The almost uniform composition of the air is accounted for—

1. By the equal distribution (taking the whole world over) of animal and vegetable life, the animals living to a great extent on the excremental gas of vegetables, and *vice versâ*.

2. By the law of diffusion of gases.

3. By the movement of the air produced by local and meteorological causes. Besides the ncessant local movement produced by the movement of animate and inanimate objects, variations in temperature and consequent variations in pressure, there is the general movement of the wind to be considered, and this, be it remembered, has a general average rate of speed in this country of ten miles an hour.

Thus the mixing of the gases is very thorough and very constant; and when (also) it is borne in mind that at the average rate of speed of the wind as much air blows over the surface of a man's body as would, at a pinch, serve for the respiratory need of 1,000, and that the supply of air is thus in great excess, and that the fouling of the atmosphere by animals is, in proportion to the whole bulk of the atmosphere, but trifling, we begin to see how it is that, in the open, the composition of the air very nearly approaches uniformity.*

The uniformity is, however, very far from being absolute. Thus, if we take the average amount of oxygen as 20·96 volumes in every 100 volumes of air, or 2,096 in every 10,000, we find that in the thickly-populated parts of the East-end of London it may fall to 2,086 parts per 10,000, while on the high ground to the North-west of the City it may rise to 2,100 parts per 10,000, which is in fact as much or more than Angus Smith found on the hills in Scotland. Thus the extreme range of fluctuation in the amount of oxygen in the open air is about fourteen parts in 10,000, or ·14 per cent.

I am not prepared to say that fluctuations of this kind have any appreciable effect on health. When we speak of air containing 21 parts per cent. of oxygen, we mean volume, not weight, so that this expression gives us no idea of the absolute amount of oxygen inhaled. Equal weights of gas or air are capable of occupying very different volumes, according to the temperature and pressure to which they are subjected. The effect of temperature is thus stated in a foot-note to Parkes's "Hygiene,"

* Professor de Chaumont, in his admirable lectures on "State Medicine," makes the following interesting and curious calculation:—"Now I reckon that at the lowest estimate there cannot be less than 300,000,000,000 cubic feet of carbonic acid generated in London in a year from combustion and respiration, or a mean of 822,000,000 per day or 34,250,000 per hour, or more than 9,500 cubic feet every second. Now, this is sufficient to double the normal amount of carbonic acid in 23,750,000 cubic feet of air every second, or in about 14 cubic miles every twenty-four hours, or more than 5,000 cubic miles per annum. This represents a mass of air of the area of the metropolis, but extending upwards to ten times the height of the Himalayan mountains. How constant and powerful must the varying currents be that produce diffusion through so vast a mass."

p. 436. "A cubic foot of dry air at 30° Fahr. weighs 566·850 grains, and is thus constituted—

436·475 grains of nitrogen.
130·375 ,, of oxygen.

At a temperature of 80° Fahr. the foot of air weighs 516·38 grains, and is thus composed—

397·61 grains of nitrogen.
118·77 ,, of oxygen.
516·38

Thus, at the higher temperature (80° Fahr.), each cubic foot of air contains 11·605 grains of oxygen less than at the lower temperature, and if we assume that the rate and depth of respiration is the same at the two temperatures, and if we further assume that 16·6 cubic feet of air are drawn into the lungs every hour, then the man in the tropical temperature, as compared with the man in the Arctic temperature, will have, so to speak, an hourly deficit of oxygen amounting to 192·6 grains.

The fire burns bright, we are told, in frosty weather, the reasons being, firstly, that those who have the care of the fire, and are themselves nipped by the frost, take care that it shall burn brightly; and secondly, the cold air which supports the combustion is rich in oxygen.

One of the great objects of respiration is to support the animal heat, and it is only one of the many instances of the absolute adaptation of means to ends which we meet with everywhere in nature, that the man who is exposed to cold is supplied with increased amount of oxygen, to cause a brisk combustion in the human furnace; while he who is scorched by the sun, and has less need of internal fire, gets a diminished supply of oxygen.

Again, diminution of pressure lessens the amount of oxygen in each cubic foot of air. If we ascend a mountain 5,000 feet high, the barometer will fall from 30 inches to 25 inches, *i.e.*, the pressure will be diminished one-sixth, and a cubic foot of air, which contained 130·4 grains of oxygen in the valley, will contain only 108·6 grains at the higher level, or a diminution of 21·8 grains per cubic foot. If we assume the rate and depth of respiration to be unaltered (which we have no right to do) then the deficit of oxygen at the higher level per hour amounts to $21·8 \times 16·6 = 361·88$ grains. These figures show that man is able to bear very great fluctuations in the weight of oxygen in the air which he breathes. They show certainly more than this, viz., that fluctuations in the amount of oxygen are necessary for his well-being under variations of temperature and pressure. Why it is that less oxygen is required to support life at great altitude is not very clear, but when we look at the hardy mountaineer, the type of health and manly beauty, we must admit that the fact is undeniable.

Although we are, at present, unable to say that the mere fact of a small per-centage variation of oxygen in the air breathed is, by itself, a very important matter, still we have to remember that it is never an isolated fact, and has always to be considered along with other facts. What we have to look to is the reason why a diminution has taken place.

Whether the small amount of carbonic acid (·04 per cent. by volume) which is present in the air serves any useful purpose in the anima economy, it would be difficult to say. Carbonic acid is regarded as an impurity, an impurity poured into the air as the result of respiration and combustion.

In the open air the amount is not found to vary to any very great extent, as the following list will show:—

Carbonic Acid, per Cent.

Over open sea (Thorpe)	·032
At Manchester (A. Smith)	·037
At Portsmouth (De Chaumont)	·032
At Aldershot ,,	·040
At Tower of London ,,	·042
At Chelsea ,,	·047
At Paddington ,,	·056
At Munich (Pettenkofer)	·050
Top of Mont Blanc (Frankland)	·061
At Chamonix ,,	·063
Arctic Regions, *Alert* (Moss)	·055

It is well known that carbonic acid in large quantities is a narcotic poison. An atmosphere containing from 5 to 10 per cent. (*i.e.*, 100 to 200 times the amount in ordinary air) is fatal. It is stated that in soda-water factories, where the amount of carbonic acid often reaches ·2 per cent., no ill-effect is felt.

The variations in the carbonic acid in the air are not very great; and it is probable that variations such as those shown above of carbonic acid per cent., would be incapable of working much, either for good or ill, but it must be remembered that carbonic acid always keeps bad and dangerous company; and when the chemist tells us that in such or such a place carbonic acid which he can analyse is in excess, we may feel sure that it

is accompanied by organic matter which he cannot analyse.

In confined spaces where human beings or animals are closely packed, carbonic acid is found in great excess. In the forecastle of a ship, the almost incredible amount of 3 per cent. of carbonic acid has been found by Rattray, and the average of 150 analyses made between decks gave 1·64 per cent. of carbonic acid. These figures are the highest which have been obtained in any place which is inhabited and inhabitable, and the explanation is to be found in the small cubic space per head, and the constant occupation of the space day and night. As much as ·58 have been found in theatres; ·70, ·50, ·30 have been found in crowded schools; ·20 in bedrooms; and similar amounts in hospitals, prisons, and other crowded places.

When the carbonic acid in a room is due to respiration, it is accompanied by a larger amount of organic matter given off by the lungs and skin, and this organic matter is but too plainly perceptible to the nose in overcrowded apartments. It is said that when in a crowded room the carbonic acid reaches ·07 per cent. the air smells no longer fresh, and that as the carbonic acid increases the foulness of the air steadily increases, till it becomes almost unbearable.

It is this organic foulness which we have mainly to fear in overcrowded places. It was the organic foulness rather than the carbonic acid which killed the victims of the Black Hole of Calcutta, and which caused symptoms of blood poisoning in those who survived.

The chief sources of carbonic acid are—

1. Respiration.
2. Combustion.
3. Putrefaction.

With regard to ozone, a great deal has been said, but in reality very little is known. It is an allotropic form of oxygen, possibly nascent oxygen freshly evolved from the green leaves of plants. It has great power of oxidation (it is said), and great power of destroying organic manner. It is usually absent in the air of towns, and present in the fresh air of the country. Its absence seems to show that the air has been, to a certain extent, used.

Taking the two chief constituents of the air—oxygen and carbonic acid—we have seen that, in the open air, their relative proportions differ so little that it is impossible to believe that the slight variations in the amounts found can ever be considered as elements of climate of any importance. The truth of this is made apparent, because we have seen that variations of temperature and pressure cause most important variations in the amount of oxygen inspired; and we have abundant proof that the highest degree of health is compatible with these variations.

Please take note that I am speaking of the open air; I leave the interior of dwellings out of consideration. Even in the best ventilated dwellings the quality of the air is far below that in the open country or the open street; while in badly-ventilated or overcrowded dwellings, the air is actually poisonous—poisonous not merely because the carbonic acid has reached a high per-centage, but rather because this carbonic acid, being due to respiration, is accompanied by odoriferous organic matter, of which we shall have more to say hereafter.

The air usually contains other chemical imgredients. Traces of common salt and ammonia are always to be found, and in the air of cities, carbonic oxide, hydrochloric, sulphuric, and sulphurous acids, in greater or less quantity. It is these latter gases which prove so deadly to all kinds of vegetation in London and other large cities. They result from the combustion of fuel and gas, and are present in such quantity that the rain which falls through the lower strata of the London atmosphere is generally strongly acid, and often proves destructive to tender plants which are heedlessly left exposed to a shower ignorantly thought to be freshening.

It is the acid in the air of London which proves so destructive to most metals, which blackens the silver, corrodes the metal fittings of our houses, gives a worm-eaten look to some of our statues, and is causing the crumbling of what is still called the New Palace at Westminster. What the effect of this acid condition of the air is upon human beings we have no exact knowledge, excepting that in cold, still weather, the mortality from lung disease in this overgrown town is apt to become almost appalling.

This condition of the air in London is, after all, you will say, only a local condition, and has no right to detain us in a discourse on climate which should include only conditions affecting countries or large districts. This is very true; but if the acid condition of the London air is a local condition, it is a local condition which affects a vast population, and is, therefore, of great importance.

Of the gaseous constituents of the atmosphere which we have mentioned, the oxygen,

nitrogen, and carbonic acid alone are constant and universally present.

Watery Vapour.

There is yet another gaseous element of the atmosphere which is absolutely universal, although the amount which is present varies immensely under different conditions. This is watery vapour.

Although this vapour is invisible, we are constantly being reminded of its presence. The moisture that condenses on the cool window panes of a crowded room, or that dims the surface of the tumbler of iced water which one may be lucky enough to get at some suffocative dinner, are among the everyday evidences that watery vapour is present in the air, and ready to condense.

Air is only capable of keeping a certain definite amount of watery vapour in an invisible condition. For equal barometric pressures the amount varies with the temperature. The higher the temperature, the greater is the amount of vapour which the air will hold invisible. At a freezing temperature each cubic foot of air will hold just over two grains of watery vapour, while at a temperature of 100° Fahr. the amount which the air will retain is close upon twenty grains, or ten times as much. These figures are not precisely accurate, but they are near enough for our purpose, and are easily remembered. When the air contains its maximum amount of watery vapour (an amount which increases with the temperature) it is said to be saturated, and if saturated air be cooled the moisture is deposited in the form of dew.

Rain, in like manner, is caused by the cooling of air saturated with moisture.

According as the moisture in the air falls short of saturation, so is its drying power, and its power of causing the evaporation of fluids. If complete saturation be spoken of as 100°, then the relative humidity of the air may be stated as a per-centage of the maximum. Let us suppose that a cubic foot of air contains 50 per cent. of watery vapour. If the temperature of the air be 32° Fahr., then we shall know that each cubic foot (containing 50 per cent. of its maximum) holds about one grain of watery vapour, and is capable of drying up a second grain. If the temperature of the air, however, be 100° Fahr., we shall know that each cubic foot (containing 50 per cent. of its maximum) holds about ten grains, and that the drying power of each cubic foot is equal to another ten.

Now it is important to bear in mind that although the air in both these imagined instances has a humidity of 50 per cent., yet the drying power is ten times greater at the higher temperature.

Since the drying power, *i.e.*, the power of causing evaporaton, is that which exercises most influence on our health and comfort, it follows that humidity must always be considered in conjunction with temperature. When the drying power of the air is great, the evaporation of fluid from our skins and lungs is great. When the drying power of the air is small, the evaporation of moisture from the skin and lungs is small also. It follows from this that a dry air is often of great use to persons suffering from what are known as chronic catarrhal conditions of the respiratory passages (throat, nose, windpipe, and bronchial tubes). The moist mucous surfaces of these parts are, as it were, dried up by the dry air which is drawn over them, and the sufferings of the invalid are greatly lessened.

As regards the effect of the drying power of the air upon the skin, it is quite impossible to consider it apart from the question of temperature, because the amount of perspiration to be evaporated depends mainly upon the temperature (exercise being left out of consideration), and hence it follows that the amount of perspiration to be evaporated may be ahead of the drying power of the air. Hence, it is not possible to consider the effect of drying power on the skin apart from the question of temperature, and we must therefore defer it until we come to talk of temperature.

The moisture in the air is due to the evaporating power of the sun. The heat of the sun is constantly raising water in the form of vapour; just as the water in a boiler is changed to vapour by the glowing fuel. In tropical regions the amount of water which is changed to invisible vapour is prodigious, but the evaporation in temperate climates is also very great, for it must be remembered that this evaporation goes on so long as the moisture in the air falls short of saturation.

The watery vapour in the air is of the greatest importance from a meteorological, and, therefore, indirectly from a climatic point of view. Mr. Scott, in his work on the "Elements of Meteorology," thinks that the distribution of moisture in the air is very local, and depends, to a great extent, on the proximity of free water surfaces to supply the moisture. It is, therefore, great in the air over tropical seas, slight in the air over extensive tropical

deserts. The amount of moisture is generally more or less in direct relationship with the temperature. The dryness of the air during a Canadian winter is well known. The water, is, to great extent, locked up in solid form, and the evaporating power of the air is slight, and hence the dry crisp atmosphere, of the pleasures of which we hear so much. The amount diminishes as we ascend in a degree rather more than proportionate to the fall of temperature. The air of high mountains is relatively dry, but the degree of moisture follows no regular law, and it has been observed by balloonists, as well as mountaineers, that in ascending to great heights, strata of air of varying degrees of moisture are passed through.

The watery vapour ever present in the air acts like a garment to the earth, an invisible robe protecting the surface of the earth, on the one hand from the scorching influence of direct solar radiations, and on the other hand preventing, to a great extent, the radiation from the earth itself, and the too rapid loss of heat when the sun goes down.

Like our own garments, the invisible watery garment of the earth moderates the heat and cold, and tends to produce equability of climate. In situations where the moisture in the air is slight, the extremes of temperature are excessive, as in flat sandy deserts, and on mountains; the heat of the sun in these situations being in striking contrast to the bitter cold of the nights.

The watery vapour ever present in the air may become visible. Were I to bring a glass of ice-cold water into this room, its surface would be dewed with moisture, because the air in contact with the glass being suddenly chilled, its capacity for moisture is lessened, and a part of it is deposited.

When the surface of the earth is suddenly chilled by radiation, dew is in like manner deposited from the strata of air in contact with it. When a clear night succeeds a hot summer day, the deposit of dew is always (in this climate) very large. Dew, it will be noticed, is always most abundant on grass and herbage, on the leaves and stems of trees, on wood and metal work, &c., while it is not present on gravel walks and in dusty roads. Dew is, in short, deposited on those bodies which lose their heat most readily by radiation.

The heaviest fall of dew which it has been my lot to witness was on a winter's morning in January, on board a yacht off Cagliari, in the Island of Sardinia. I was roused about half-past seven by the pattering, as I thought, of heavy rain upon the deck, but on going on deck I found that the shower was exceedingly local, being produced by the deposit of dew upon the high spars and rigging of the yacht, and its subsequent descent upon the deck in a heavy shower. The power of the sun on the previous day had been very great, and had raised much vapour from the sea, and this moisture-laden air being cooled by contact with the cold spars and rigging, discharged its moisture in the manner related.

Humboldt has recorded how, in some of the forests of South America, the traveller on entering a wood finds, apparently, a heavy shower falling, whilst overhead the sky is perfectly clear. The formation of dew takes place on the tops of the trees, and so copiously, owing to the abundance of vapour in a tropical atmosphere, that a real shower of rain is the result.

Fogs and mists are due, it is now generally supposed, to the condensation of moisture on the infinitely fine particles which are always suspended in the air. If the air be absolutely free from dust, watery vapour forms no mist, but the presence of solid impurity determines a fog. For the formation of fog three things are necessary:—

1. The cooling of moisture laden air.
2. Calm weather, so that the mist is not blown away as soon as formed.
3. Solid matter in the air.

When in winter the south-east wind blows, bringing moisture-laden air from the German Ocean and the Channel, up the estuary of the Thames, and when this moist air comes in contact with the cooler air of London, charged with solid impurity to an enormous extent, a London fog is the result. The fogs of Newfoundland are due to the chilling of moist air by coming in contact with a surface of water cooled by melting ice.

Most of the water evaporated from the surface of the salt and fresh waters of the globe returns to the surface in the form of rain.

Rain is produced by the chilling of air more or less charged with moisture. Near the equator the hot air charged with moisture rises into the cooler regions of the atmosphere, and descends again as rain, and in torrents of which we have no knowledge in these latitudes. Air which has traversed a large tract of sea, like that which comes to us from the south and west from off the surface of the Atlantic, is charged with moisture. As it strikes against the precipitous hills of our western coasts, it is

chilled by the colder land, and, at the same time, is driven upwards by the conformation of the hills, and the result is that the moisture is deposited in the form of rain. Hence it follows that the south-west corner of Ireland and the western coast of England and Scotland are the wettest parts of the British Isles, and in great contrast to the eastern coasts.

The wettest parts of the globe are those where winds blowing from tropical seas strike against the chilled tops of high mountains, and probably there is no place with greater rainfall than the district which lies at the eastern extremity of the Himalayan mountains, where the rainfall is said to amount to as much as 400 inches a year.

Winds laden with moisture lose it at the first opportunity. Thus the south-west winds in this country cause heavy rainfalls on our western coasts, amounting to as much as 150 inches per annum in some parts of Cumberland. The winds, thus dried by a fall of rain, can cause but little rainfall elsewhere, so that in our eastern coasts the rainfall is not more than 20 inches.

The centre of great continents are necessarily dry. The middle of Australia, Sahara, in the centre of Africa, and parts of Central Asia, are among the driest regions of the world.

What are the effects of moisture and dryness?

It is a well-known fact that when water is evaporated and turned into invisible vapour, that a certain amount of heat becomes latent, as it is termed, and cold results. When, on the other hand, watery vapour is condensed and becomes liquid, the latent heat is given out, and hence rain has a great power of warming the air. Professor Haughton has calculated that, on the west coast of Ireland, the heat derived from the rainfall is equal to half that derived from the sun.

The presence of rain-clouds has, of course, a great influence on the temperature of a district, as, by obstructing the sun's rays, they prevent the heating of the surface.

On the other hand, clouds equalise the temperature by preventing radiations of heat after sunset. Cloudless nights are cold nights, because of the comparatively unobstructed radiation. These are the nights when the gardener covers up his tender plants, and looks to his greenhouse fires. Cloudy nights, on the other hand, are warm.

Rainfall has a very purifying influence on the air, by washing it of its solid and some gaseous impurities. Who has not watched a thunder shower after a spell of dry weather in London, in July or August? Previous to the shower the air is oppressive, and has a smoky ammoniacal smell, and the wooden pavements, kept moistened by the watering carts, smell like a stable. With the first drops of the shower, "blacks" as big as blue-bottle flies are driven downwards from the upper strata, these diminish as the shower continues, and soon the air smells fresh and wholesome.

As to the effect of moisture upon health, not very much is known.

Rainfall purifies the air, and if it be not sufficient to prevent exercise it apparently does no harm. When the air is hot and moist, so that evaporation, with its consequent cooling, cannot be effected on the skin, it is very oppressive. Moist air is most grateful to persons with dry chronic coughs.

There is one way in which moisture affects health, and which has been not much considered hitherto, and that is the effect which it has on the process of decay and putrefaction. Putrefaction, as is well known, is favoured by warmth and moisture, and is checked by cold and dryness. Warmth and moisture for the most part favour the growth of bacteria and other allied micro-organisms, some of which are definitely known to be directly connected with epidemic disease, while cold and dryness check them.

Parkes ("Practical Hygiene," page 37) remarks:—

> "The spread of certain diseases is supposed to be intimately connected with the humidity of the air. Malarious diseases, it is said, never attain their fullest epidemic spread, unless the humidity approaches saturation. Plague and small-pox are both checked by a very dry atmosphere. The cessation of bubo plague in Upper Egypt after St. John's-day has been considered to be more owing to the dryness than to the heat of the air.
>
> "In the dry Harmattan wind on the West Coast of Africa, small-pox cannot be innoculated, and it is well known with what difficulty cow-pox is kept up in very dry seasons in India."

If infective disease be due to organisms, and if the growth of these organisms depends upon conditions similar to those that regulate the activity of putrefaction and fermentation—facts in which there is a daily increasing belief—then we must come to the conclusion that dryness and cold both check one class of diseases, and that the biting dry east winds in this country, and the much abused north-west wind which is known as the mistral in the south of France, are, although pitiless,

and indeed often deadly to the sick and weakly, among our best friends from the point of view of health.

From the point of view of exercise and comfort, the absolute annual rainfall of a district is of less importance than the number of rainy days per annum. There is no necessary relationship between the annual rainfall and the number of rainy days; in fact, they often bear an inverse proportion to each other.

If we propose to visit a particular spot in search of outdoor exercise, pleasure, and health, this point of the number of rainy days to be expected is one of very great importance. Thus, at Valentia, on the west coast of Ireland, with a very mild even temperature, some 235 wet days per annum may be expected. According to Hassall, who is quoted by Weber, there is, at Torquay, an average rainfall of 36 inches, with 200 rainy days; at Ventnor, 34 inches, with 174 rainy days; at Cannes, 35 inches, with only 70 rainy days; at Bournemouth, 28 inches, with 156 rainy days; and at San Remo, 28 inches, with only 48 rainy days.

Although I have no doubt these figures give a fairly correct notion of the relative raininess of the places mentioned, we must, nevertheless, be careful how we build our hopes upon average numbers. The average is sometimes calculated upon too small a number of years. Sometimes the years upon which the average is calculated are, so to say, picked, and the calculation, actuated by local bias, has begun with the year after, and stopped short of a year when some extreme number has been reached. Even supposing that the averages are in every way just, we must still remember that there are extremes as well as means, and we may have the bad fortune to visit a spot with a dry reputation and get a daily drenching. Such was my luck at San Remo, in the month of February, 1883.

Temperature.

Having considered the atmosphere—its gaseous and watery constituents—in its relation to climate and health, we now turn to something which is, as it were, outside of and independent of the atmospheric garment in which the earth is clothed, but which influences us mainly through the instrumentality of the atmosphere. I allude to temperature.

The main source of the earth's heat is the sun, which is distant from us some 92,000,000 of miles, and it is worthy of remark that, owing to the elliptical orbit of the earth, we are about 3,000,000 of miles nearer the sun at our mid-winter than we are at our mid-summer. It is evident, therefore, that the seasonal variations of temperature do not depend on the varying distance of the sun.

The seasonal variations of temperature depend on the verticality or obliquity with which the sun's rays strike the surface of the earth, for the more vertical is the path of the sunbeam the more concentrated is its effect, and the thickness of atmosphere which it has to traverse is at its minimum. When the sunbeam falls obliquely its effect is more dispersed, and the thickness of atmosphere which it has to traverse is at its maximum. Therefore, when the sun is most vertical, *i.e.*, at Midsummer, and at midday, we derive most heat from it, and when the sun is "low in the heavens," as at mid-winter, and at dawn and evening, we derive less heat.

Much of the radiant heat of the sun is absorbed by the watery vapour of the atmosphere before it reaches the earth. The greater part of this absorption takes place in the lower strata of the atmosphere, and it is well known that, as we ascend out of the lower strata into the dry rarified air of high mountain ranges, the radiant heat derived from the sun is excessive.

The direct radiant heat of the sun passes through the atmosphere without materially raising its temperature, but the temperature of any solid upon which the heat rays fall, such as the soil, the human body, or the blackened bulb of a thermometer, is materially raised. In this country temperatures of 150° Fahr. have been marked by blackened thermometers in vacuo, and in situations where the atmosphere is very dry and very rarefied, "as at Leh, in Ladakh, to the north of Cashmere, at an elevation of 11,000 feet, the readings have gone up to 214° Fahr., and even higher." (Scott, "Elementary Meteorology," p. 56).

"It is a well-known phenomenon that, at considerable elevations above the sea-level, where the denser and damper portions of the atmosphere is beneath us, the direct effect of solar heat is quite disproportionate to the temperature of the air. In such localities, as for instance, at Davos, in Switzerland, at the level of 5,000 feet, you can sit in the sun comfortably without a great coat; while in the shade close by, the temperature is several degrees below the freezing point. In high latitudes the same paradox is observed where the extreme dryness of the atmosphere is due to intense cold. The observation is as old as the time of Scoresby, that on board a whaler you may see the pitch bubbling out of the

seams of the ship where the sun shines on them, while ice is forming on the sides of the ship which is in the shade." (Scott, *loc. cit.*)

In this damp climate, we have hardly any knowledge of the difference which may exist between the temperatures of sunshine and shade, and the difference is one of the first novel experiences of those who visit sunny dry climates, whether at great elevations or elsewhere. In the south of France, along the Riviera, where the air is much drier and the sun more powerful than here, during the prevalence of the dry, cold mistral, to step from sunshine into shade is almost like stepping into a cold bath; and at Marseilles, on one occasion, I well remember standing with my back to the sun until the calves of my legs were fairly scorched with the heat, while my toes, which were in the shadow of my legs, were uncomfortably nipped with the cold.

It is evident that British visitors to these climates run great risks of catching cold, because the sudden alternations of temperature are phenomena to which they are entirely unaccustomed. They are apt to be too lightly clad, and to forget that while the direct rays of the winter sun afford a temperature which reminds us of our July, cold, as severe as that which we experience at home, is lurking in the shade.

The most characteristic feature in the dress of the inhabitants of Southern Europe is the loose, full cloak, so arranged that it may be discarded, or made to closely enwrap the body at a moment's notice. Necessity is the mother of invention, and this cloak has been necessitated by climates in which the alternations of temperature are sudden and severe.

Since radiant heat experiences most difficulty in traversing the damp lower strata of the atmosphere, it follows that its effects are less felt in the neighbourhood of large surfaces of water, where the air is always humid, than elsewhere; and insular climates are, as a rule, less hot than the climates of adjoining continents.

The radiant heat having penetrated the atmosphere, in greater or less quantity, according to circumstances, some of which we have alluded to, what becomes of it?

1. Some of it is absorbed by the surface upon which it falls.

2. Some of it is reflected back, and these reflected rays, added to the direct rays, very much increase the heat of solid bodies exposed to them.

The power of the earth to absorb heat varies very much, according to the nature and aggregation of the soil. Assuming the maximum absorbing power to be equal to 100, then Schubler has calculated that the absorbing power of—

Sand, with some lime	=	100
Pure sand	=	95·6
Light clay	=	76·9
Heavy clay....................	=	71·11
Fine chalk	=	61·8
Humus	=	49

Herbage of all kinds lessens the heat-absorbing power of the soil.

Colour makes a difference to the absorbing power also, and, generally speaking, dark coloured soil and surfaces absorb much heat. Soil and surfaces not only absorb heat but reflect it also, and it may be said that the amounts of heat absorbed and reflected by any surface bear an inverse proportion to each other. Among reflectors of heat which will occur to all, are snow, water, and white chalk cliffs and rocks of all kinds; the presence of these reflectors necessarily intensifies the power of heat upon an individual, or any object capable of absorbing it.

Soils and other surfaces, which have been warmed by absorption of heat during the hours of sunshine, lose this heat again by radiation during the night. Radiation is helped by a clear, dry, atmosphere, and is impeded by a moist atmosphere, or by a canopy of cloud which checks it almost entirely. As a rule, it may be said that soils lose heat by radiation sooner than they gain it by absorption. Soils and solids generally are quickly heated, and quickly cool again.

With water it is different, and seeing that this earth's surface is mostly water, it is very important that we should consider the effect of heat upon water.

In the first place, the atmosphere over the sea or large sheets of water is always more or less charged with moisture. Hence the heat-rays have some difficulty in penetrating the atmosphere to reach the water, and the water, when once heated, experiences from the same cause, so to say, a difficulty in losing its heat by radiation. Again, much of the radiant heat which falls upon the surface of the sea is reflected, and not absorbed.

Thus we have given two reasons why the surface of the sea is not so readily heated as the surface of the soil. Further than this, we have to consider that the heat rays penetrate to a considerable depth into the water (some

600 feet), and do not, so to say, waste all their energies upon the surface.

Lastly, and most important, the specific heat of water is very high, about four times greater than that of land; and for the heating of equal bulks much larger quantities of heat are necessary in the case of water. The heating of water is much slower than the heating of land, and it loses its heat by radiation much more slowly, and for the following reason :—As the layers of water on the surface cool, they get heavier and gradually sink, and warmer water rises to the surfaces. Hence it follows that the sea never gets heated to an excessive extent, and on the other hand, owing to the circulation of the fluid, it never gets chilled to an extent at all equal to the neighbouring land. In polar regions, when water ceases to be liquid, these conditions cease. The sea is, therefore, a great cause of equable temperature, and on its surface and by its shores it may be laid down as a rule that extremes are moderated.

The temperature of the surface of the sea in the tropics reaches about 85° Fahr. as a maximum, while the surface temperature in these latitudes fluctuates between 60° Fahr. as a maximum, and 35° Fahr. as a minimum. If we change the temperature of part of a volume of water, we cause changes of density, and, as a consequence, movement of the mass. Hot water rises, cold water flows in to fill its place. What happens to the oceans which lie between the blazing tropics and the frozen poles? These great masses of water obey physical laws, and there is a constant stream of cold water at the bottom of the ocean, flowing from the poles to the tropics, and, broadly speaking, a flow of warm water on the surface in the opposite direction.

The heated water of the surface not only flows to take the place, as it were, of the sinking cold water of the Poles, but it is blown by prevailing winds, and gets a direction in this way or that by the shape or bendings of neighbouring coast lines. In these islands we ought to be deeply grateful to ocean currents. The general oceanic circulation, and the so-called Gulf Stream, which is in fact a part of it, laps our coasts in warm water, and prevents us from experiencing the wintry rigours which are felt in Upper Canada and Central Russia, places in the same latitude as ourselves.

With this short review of the causes of variations in temperature, we may now particularise a little, and discuss the causes which affect the temperature of localities.

1. *Latitude.*—The length of daily exposure to the sun's rays, and the degree of obliquity or verticality at mid-day, are important elements in determining the temperature of a place. If the surface of the earth were uniform, then latitude and temperature would be in exact relation, but this we know is very far from being the case.

2. *Elevation above Sea Level.*—As we rise above the surface, the temperature of the air falls about 1° Fahr. for each 300 feet of ascent. Hill stations are, therefore, always cooler than stations situate in the plains of the same latitude.

3. *Amount of Cloud and Moisture in the Air.*—These serve as curtains against the sun's rays, and depress the temperature while the sun is shining. On the other hand, they check radiation when the sun has set, and preserve the warmth at night.

4. *The Nature of the Surface.*—Land heats and cools far more readily than water, and, therefore, in the centre of great continents extreme fluctuations are common. The nature of the soil is of importance, as we have seen. The sea moderates temperature, preventing excessive heat, and the extremes of cold. The stretch of water between these islands and the Poles helps to keep them warm, and moderates the bitterness of northern winds. The warm currents from the equatorial Atlantic help also to keep us warm. In Canada and Russia, which enjoy neither of these advantages, the winters are in great contrast to our own.

5. *Prevailing Winds.*—In this climate the south-west winds, laden with rain, are a great cause of warmth, and produce the high winter temperatures of Valentia, on the west of Ireland, of Scilly, and of the islands on the west of Scotland. As a contrast to these places in our own country, let us take the city of Turin, which enjoys a greater sun exposure it is true, but which is exposed to the bitter winds blowing from the snow-clad Alps, and where the serene skies of winter allow uninterrupted radiation of terrestial heat.

6. *Position of Hills and Mountain Ranges in respect of Locality.*—If the hills are between the locality and the sun, they help to depress temperature. We all know the difference between a northern and a southern exposure. If the hills protect the locality from cold winds, and help to reflect the sun's rays, then they increase the temperature of the locality.

Having got so far, it will be well to take a familiar example, and inquire the cause of the climate of one very well known place.

Let us look at that favoured spot in the south of France, known as the Riviera, where our countrymen flock in search of pleasure and of health, of warmth, sunshine, and natural beauties. The climate of this spot, be it observed, is warmer and more equable than that of places farther south, such as Florence, or even Naples, so that its climatic advantages are by no means entirely due to latitude. The sun is more powerful than with us (for the locality is some eight or nine degrees south of London), and in the winter remains somewhat longer above the horizon, so the intensity and the length of sunshine is greater than here. There is far less cloud, and the prevailing winds are less moist, so that the power of the sun's rays to penetrate the atmosphere is greater than here. The soil is dry, and this aids in producing a comparatively dry air, the moisture amounting to about 70 per cent. as against 90 per cent. in London. At a varying distance from the shore are the lower spurs of the range of hills known as the Alpes Maritimes. These serve a double object (1), they protect the locality from the cold winds which blow from the ice-fields of the Alps; and (2), they reflect the sun-heat just as a plate warmer before the fire reflects the heat upon the plates. This is a great cause of the warmth of this favoured district, and of the lovely semi-tropical vegetations which there abounds.

Another important fact is the proximity of the land-locked Mediteranean Sea. In this sea are no Polar currents, although there is doubtless some circulation and some warm surface currents blown from its southern shores. The deep sea temperature of the Mediteranean is over 50° Fahr., while that of the Atlantic outside the Straits of Gibraltar is only 36° Fahr. In this spot several of those conditions which conduce to a warm temperature come together, and its popularity with physicians and the public is not to be wondered at.

There is no such thing as a climate which any of us would ignorantly and selfishly call perfect. Even the favoured Riviera has its drawbacks, and the staple of conversation among the more delicate of the frequenters of this part of the French coast is the "mistral," the north-west wind, dry, cold, and boisterous, which, after traversing the centre of France, forces its way through the gorges and round the spurs of the Alpes Maritimes, and sweeps rudely into the sacred warming pan which lies between Toulon and San Remo. When the mistral blows, the sky is clear and bright, the air is dry and crisp, and, if escape can be found from the clouds of dust which it raises, it is stimulating, and not unpleasant to a man in good health, who is able to move about and warm himself by exercise. The mistral is most intolerable in a town, where it sweeps down the streets and round the corners with a fury positively dangerous to feeble people, and accompanied by clouds of dust which must be no bad imitations of the dust storms of the desert. The mistral is very chilling, and very irritating to persons with weak lungs, and the only thing for invalids to do while it is blowing is to sit indoors, and if they have sunny windows facing the south-east, they will much enjoy the bright sky and warmth, and will not feel the wind.

The mistral, as I have previously hinted, is probably one of the best friends of this coast. It must be the most potent scavenger, drying up filth, holding putrefaction in check, and purging many a foul corner of its dangerous accumulations. Another drawback to the Riviera is the wide range of temperature, which is a snare to the unwary. Between sunshine and shade there is often a difference of 73° Fahr., and between midday and midnight the difference is equally great. Insufficient clothing, and careless exposure after sunset or to night air, has cost many an invalid his life.

The extremes of temperature which may be encountered on the globe are very remarkable. The average temperature for the month of May at Massowah, in the Red Sea, is (according to Scott) 99° Fahr., while the winter average for Werchojansk, in Siberia, is—56 Fahr. There is, therefore, a range of 155 degrees between the hottest month at Massowah and the coldest month in the heart of Siberia.

Sir John Herschel has recorded a temperature of 159° Fahr., observed on sandy soil at the Cape of Good Hope, and the lowest actually recorded temperature is —81° observed by Gorochow, in Siberia. As to the endurability of these extremes, Scott quotes Dr. Moss, who, in his "Stories of the Polar Sea," says:—

> "Many a time the relative merits of Arctic cold and tropical heat were warmly canvassed. Many of our officers and men had lately returned from the Ashantee campaign, and they could speak with authority. There was one thing clear, one could sometimes get warm in the Arctic, but never cool on the coast."

Nothing is more calculated to rouse our

admiration and amazement than the manner in which the animal body accommodates itself to extremes of temperature. Men will go from tropics to Pole and from Pole to tropics, and maintain a fair level of health at both, and we may well pause to inquire how this is managed.

Life in the tropics is a simple matter. There is no necessity for clothing or firing, and a handful of dates will almost supply the food wants of the individual. Protection from wild animals and from fellow men is almost the only thing necessary to preserve life.

A naked animal like man could hardly move far from the tropics until he had learnt a little tailoring, and had found out how to turn the skins of the lower animals to his own account. The art of building huts or tents would enable him to move still further north, but without the great discovery of fire he could hardly have penetrated into cold climates, and still less could he maintain an existence there. The great trouble in the Arctic regions is to keep up the animal heat, and this is only to be done—(1) by the adoption of every kind of artificial protection against cold, and (2) by the supply of sufficient food, which is often no easy matter. Food in abundance is most important, as without it the temperature of the body cannot be maintained. The Esquimaux will consume ten pounds of animal food per diem. Food is the fuel which we put into the internal furnaces of our bodies. In a week or two the lambing season will begin, and many of us will wonder how the delicate younglings manage to support so much cold and exposure; but the farmer will tell us that, provided there be food enough for his ewes, and, by consequence, milk enough for the lambs, he has no fear of snow and cold, at least in moderation.

One advantage of an Arctic climate is the total suppression of putrefaction, and the inability of animal and vegetable parasites to get a hold of our bodies.

The effects of temperature *per se* upon the animal body are very difficult to determine, as it is almost impossible to separate temperature from other conditions which follow in the wake of, or accompany, extremes of temperature.

If the temperature of the blood be raised higher than 113° Fahr., life is scarcely possible, because at that temperature myosin coagulates and the muscles become rigid. Although in the tropics the direct rays of the sun may raise objects upon which they fall to a temperature not far short of that of boiling water, yet the blood temperature is not raised to any great extent above normal (98°·4 C.) so delicate is the machinery for regulating the temperature of the animal body. When the temperature of the body is raised, it is probable that the conducting power of the nerves is lowered, and this again is a source of danger to life. When the direct rays of the sun fall upon the head and the nape of the neck, it occasionally happens that the heat-regulating machine of the body is paralysed, and then we get what is known as sunstroke or heat apoplexy. The same accident may occur in the shade when the temperature of the air is high. It is a great question whether high temperature *per se* is sufficient to produce heat apoplexy or sunstroke. This accident has often been associated with conditions which induce foulness of the air as well as heat, and Dr. Parkes points out that sunstroke and heat apoplexy are very rare at sea, or on mountain heights, notwithstanding that the effect of the sun's rays is very intense in these situations. Very often clothing and dirt seem to have conspired to render the victim intolerant of heat, and unable to regulate the temperature of his body.

There is some evidence to show that when an inhabitant of a temperate climate voyages to the tropics, there is slight elevation of body temperature which, however, at the most, is less than 2° Fahr. After a short time the increased action of the skin equalises the temperature, which is maintained at about 99° Fahr., a heat which appears to be that which is most favourable for the performance of vital functions. Dr. Rattray has shown that the respirations in the tropics become slower and somewhat deeper, and that the respiratory function is lowered to the extent of about 18 per cent., so that if a man gets rid of ten ounces of carbon by the lungs in a temperate climate, he will only eliminate a little more than eight ounces in the tropics.

Parkes and Francis have both noticed that the lungs of Europeans dying in the tropics become lighter and weigh less than the normal *post-mortem*. Not only is the respiratory function lessened, but the amount of oxygen per cubic foot of air is lessened also, as we have seen. This lowered respiratory function must have the effect of lessening heat production.

Heat increases the action of the skin, but is said to lessen the activity of the heart and kidneys, to lessen the digestive power, and to lower the nervous energy of the body. Rattray's observations on naval cadets show that in the tropics the increase of height was considerable,

but notwithstanding this, most of the lads under observation (48 in number) lost weight.

Cold.—How little effect mere cold has upon the health is shown by the interesting but trying experiences of the crew of the *Eira*, the yacht which was fitted out by Mr. Leigh Smith for the purposes of Arctic exploration in the year 1881. The *Eira*, it will be remembered, left Peterhead on June 14th, 1881. When she had reached Cape Flora, in Franz Josef Land, a point near the 80th parallel of north latitude, the yacht was nipped in the ice pack, and quickly sank. The crew and a good deal of the cargo were got on shore. The account given by Dr. W. H. Neale, the medical officer of the expedition, is full of interest. This gentleman says, in a communication to the *Lancet* in August, 1882 :—

> "I am afraid there is very little to say, in a medical point of view, with regard to the late Arctic expedition of Mr. Leigh Smith, its great characteristic being the singular absence of disease among a crew of twenty-five men, during a sojourn of fifteen months in the Arctic Regions."

Two men who were invalids before they started, and who ought not to have been allowed to join the expedition, remained ill the whole time, and returned home invalided, but beyond this, there was no sickness worth speaking of.

A considerable quantity of preserved provisions was saved from the wreck, together with tea, tobacco, and rum, and, luckily, some firearms and ammunition were also saved, so that there was no lack of fresh meat, chiefly walrus and bear. There was no lack of food. They were able to have, collectively, from 25 to 50 lbs. of fresh meat every day, together with 12 lbs. of tinned vegetables, tea night and morning, one ounce of rum, and a quarter of a pound of flour made into a "dough-boy." Thus there was no question of scanty rations. The meat was made into soup, and to the soup some of the blood of the animal was added, and this, it is said, greatly improved its quality. If, however, the dietary was passable and endurable, what were the other conditions? A hut was built of stone and turf, 38 ft. by 12 ft., and with an average height of 5½ ft. This was divided into three compartments by canvas partitions. One of these, containing about 1,250 cubic feet of space, served as the forecastle, and here twenty men slept with a little more than 60 cubic feet of space each.

The middle compartment, containing about 660 cubic feet of space served as the kitchen, and the third compartment, with about 594 cubic feet, served as a store-room for provisions, &c., and as the sleeping apartment for Mr. Leigh Smith, Dr. Neale, the ice master, and the two invalids. In planning the hut, the ventilation had been carefully considered. The doorway opened into the middle compartment, and was approached by a long porch (seventeen feet long), and opposite the door was the kitchen fire. A sail served as a door, and through this door there came a free current of air, and ventilation was further provided for by putting some old meat tins through the roof, the lids being put on or taken off the tins at pleasure, and according as the weather and snow permitted. Notwithstanding that the ventilation had been so wisely provided for, it is evident, considering the small cubic space per man, and the excessive coldness of the incoming air, that the supply of fresh air must have been almost incredibly small. The temperature of the outside air was −43° Fahr., and often lower than this for hours together. Sixty-five degrees of frost! We are told that a temperature of 20° Fahr. was considered warm in the captain's sleeping apartment, and that the thermometer often stood at zero Fahrenheit on the ground in the kitchen.

"Our clothing," continues the narrative of Dr. Neale, "was scanty, consisting of woollen and flannel garments; no skins or furs of any kind were worn, and I do not think they are necessary, unless one is sledging, or obliged to go out in all weathers to make observations." For ten long months these men led this life, enduring the intense cold and the prolonged darkness. At the end of it they bore the hard work of a six weeks' journey across the ice, and were ultimately picked up by Sir Allen Young, all sound and well.

There was no trace of scurvy to be found in any of the crew, a fact attributable to the daily supply of fresh meat. One man had an attack of bronchitis and pleurisy, which kept him to the house for three weeks, and another was ill from bronchitis for a fortnight. This was the sum total of lung disease, and, be it observed, recovery took place at least as rapidly, if not more so, than usually is the case in London. There were slight cases of frost-bite, easily cured, but no severe cases. There was some trouble with the digestive organs at first, but when the men got accustomed to their novel diet, this at once subsided. When the sun appeared in the spring, snow blindness was troublesome. In short, when they were picked up by Sir Allen Young, they were all well and ruddy, and Dr. Neale notices it as worthy of

remark, that the almost total lack of light in the winter had no effect in producing pallor.

It is also a remarkable fact that, although washing was impossible for weeks together, there was no appearance of vermin upon the heads or bodies of any of them, a fact which seems to show that a temperature of minus forty-three is not favourable for parasites.

I had the pleasure of meeting Dr. Neale, within a few days of his return to London, and he looked, as one would say, "the picture of health," ruddy, and plump.

This interesting narrative shows that the extremes of cold and darkness do not necessarily of themselves endanger life.

LECTURE II.—DELIVERED JANUARY 19, 1885.

THE FLOATING MATTER IN THE AIR.

It is a well-known and universally acknowledged fact that different climates are inhabited by different animals and plants. It is also well known that animals and plants, which are indigenous to tropical and warm climates, quickly die in colder regions, unless artificially protected. In Polar regions vegetation becomes exceedingly scanty, although the Polar seas teem with animal life. Animal life is more easily supported in cold countries than is vegetable life. Man, as we have seen, is able to encounter for months the very extremities of cold without any detriment to his general health, but he is enabled to do so only by artificail help from clothing and firing, by building a warm hut for shelter, and by packing close into this hut for the sake of mutual warmth. The conditions under which the crew of the *Eira* enjoyed such rude health in Franz Josef Land, conditions of which overcrowding and dirt were the chief characteristics, would be stigmatised in this or any temperate climate as most unhealthy, and such as would certainly quickly prove highly prejudicial, and in all probability cause sore throats, lung disease, consumption, and other troubles.

Such conditions of life in the tropics would be scarcely less fatal, probably, than was the Black Hole of Calcutta. Why is it that conditions of life which would be fatal in the tropics are apparently harmless at the Pole?

The only explanation which I am able to offer is this, that at the Pole, putrefaction, decomposition, and decay of effete matters is, owing to the low temperature, impossible. What we call dead organic matter becomes a prey to lower forms of life, both animal and vegetable; but in the Polar regions these lower forms of life, if existent, are unable to manifest any vitality, and those processes, of which putrefaction is the type, are in abeyance.

The extreme cold and the extreme dryness of Polar regions are both opposed to anything like putrefactive change; and it is a remarkable fact that among the Eskimo (who absolutely never wash, who inhabit their clothes almost as continuously as they do their skins, and who live in a state of filth without its parallel in the world) filth disease should be conspicuous by its absence. If cold and dryness check putrefaction, warmth and moisture equally encourage it, and in tropical climates (unless the dryness of the air is very great), putrefaction runs riot, and diseases dependent upon the decay of organic matter run riot also.

Up to this point we seem to have arrived at certain conditions:—

1. That the varying chemical constitution of the atmosphere has no great effect upon health.

2. That the amount of moisture in the air may vary considerably, and by so doing may cause a certain amount of comfort or discomfort to invalids, but that the humidity of the air has no great effect upon health, except in so far as it effects the processes connected with putrefaction and decay.

3. That the extremes of heat and cold *per se* can be borne by healthy men under favourable circumstances without any very serious results; but that a high temperature is indirectly dangerous, because of the facilities which it offers, so to say, to all putrefactive changes.

As far as we have gone, we seem to be landed in the conclusion that none of the atmospheric conditions we have considered are of necessity directly harmful to the individual; but that,

indirectly, those conditions which favour putrefactive and allied changes may be very prejudicial to his health.

A glance at two of the diagrams suspended from the screen will serve to show you that there is a most unmistakable connection between the temperature of the air and the death-rate from two classes of disease.

The first shows that the deaths from diseases of the respiratory organs rises as the temperature falls; or, in other words, that in cold weather, death from lung disease reaches its maximum. We must not conclude from this that cold, *per se*, is the great cause of lung disease, for I shall probaby convince you, before these lectures are finished, that overcrowding, intemperance, starvation, and a sewage-sodden soil, are more active causes of this form of disease than cold.

To persons whose lungs are already diseased, cold is very trying, and the extremes of cold kill off, as it were, the sufferers from lung disease more than they cause the disease itself. Again, old people are liable to suffer from inflammation and congestion of the lungs; and in fact, this is one of the recognised ways in which death comes to the aged, so that many of the deaths registered in very cold weather as deaths from lung disease, are, in reality, those of very old people, and others whose debt of nature was due, or over due.

The other diagram shows that during periods of high temperature the mortality is high from diarrhœa. The cause of this diarrhœa is probably to be found in the facilities afforded by high temperature for putrefactive change. In warm weather, as we know, milk "turns," meat goes putrid, fruit gets rotten, and all collections of putrescible matter are more than usually offensive to the nose. The sewer gratings smell, and the kitchen sink is malodorous in warm weather; and it is in warm weather especially that we write to *The Times* to complain of the filthy condition of our Father Thames. The consumption of putrid food, and the inhalation of putrid air, are both acknowledged causes of diarrhœa; and it is probably *viâ* putridity, so to say, that summer raises the death-rate from diarrhœal diseases.

As we advance into the tropics, speaking generally, the amount of disease increases; and if we look at Keith Johnston's map of the "Geographical Distribution of Disease" we find that the chief diseases are—

1. Malarious diseases (fever, ague, and dysentery).
2. Yellow fever.
3. Cholera.
4. Typhoid, and allied forms of fever.
5. Ophthalmia.

Now each of these diseases I have named is certainly connected with putrefactive and allied conditions. Malaria is caused by decay of organic matter in marshes and similar places. Yellow fever is a disease mainly of the cities of the western tropics, and is certainly mainly dependent on the putrefaction of fæcal and other animal matters. Of cholera it may safely be said that fæcal discharges are one medium for its propagation, and that it gets its strongest hold where putrefying filth is allowed to pollute the soil and air. Typhoid is a recognised filth disease; and ophthalmia, which is the scourge of Egypt, and other Mediterranean stations, has been clearly shown, in more than one instance, to depend on air fouled by fæcal decompositions.

Here, then, we find that an enormous proportion of tropical disease, if not wholly dependent on, is in some way inseparably connected with, the putrefaction and decay of organic matter, whether vegetable or animal.

Undoubtedly, one of the greatest scientific advances which has been made in the present day was made by Pasteur, when he demonstrated that fermentation and putrefaction were due to the growth of low forms of vegetable life at the expense of the fermentable or putrescible liquid; and that if the aforesaid vegetable organisms can be excluded from the fermentable or putrescible matter, then neither fermentation or putrefaction will take place, and the fluid will remain unaltered, even for years.

Unless special precautions be taken, any putrescible fluid, if left to itself, will putrefy. How is this brought about? The answer is, that the active agent of the putrescible change is supplied by the surrounding media. The soil, the water, a neighbouring putrefactive focus of some kind, supplies the necessary organism; this is wafted through the air, and sets putrefaction agoing in the putrescible fluid.

Apart from all other considerations, this undesirable sequence of air-borne germs, putrefaction, disease, is enough to invest with the deepest interest the question of the floating matter in the air, to which we shall now, for a short time, turn our attention.

A London audience, I feel, is not unlikely to have some sort of prejudice in favour of the proposition that floating matter does exist in the air, and that in no small amount.

As to the nature of the matter which may be found floating in the air, the variety is infinite, and the distance which floating matter may be carried by the air is also very variable. Thus I have the authority of Mr. Buchan, the author of the article, "Meteorology," in the Encyclopædia Britannica," for stating that 'The tornado which passed over Mount Carmel (Illinois), June 4th, 1877, swept off the spire, vane, and gilded ball of the Methodist church, and carried it bodily fifteen miles to the north-eastward."

Again, whirlwinds occasionally raise the fine sand of African deserts high into the atmosphere, whence it is wafted distances which seem incredible, and has been known to fall upon the sails of ships 600 or 800 miles away; and in the city of Berlin have been found organisms which, according to the learned, must have had their origin in African deserts.

The fact that comparatively large and appreciably ponderable particles can be carried such long distances through the air, will prepare the mind to accept without difficulty the proposition that particles so attenuated as almost to elude the grasp of the mind's eye may be transported any distance.

This important question of the solid matter in the air has, for some years past, been attracting an increasing amount of attention. The dust which is deposited in sheltered places comes from the air, and many microscopical examinations and chemical analyses of dust have been made. The dust of Dublin was found by Tichborne to contain from 29 to 45 per cent. of organic matter, which was chiefly composed of finely ground horse droppings; and among the unpleasant things which have been found in dust may be mentioned:—Scales from the human body, the dried matter from suppurating wounds, the insects which produce the disease called itch, the fungus which causes ringworm, and scales from small-pox pustules.

Reading such a list as this we cannot help feeling that the potentiality for evil of dust and dirt may be very great, and the natural reflection will force itself upon us, "Do these things, and such as these, become dried, and then, lifted by the wind, and carried through the air, work mischief at a distance from their source of origin?" The floating matters in the air are mineral, vegetable, and animal. If air be directed through a suitable apparatus, the details of which I need not trouble you with, the solid particles will be deposited, and may be examined with the microscope. In dust collected in this way microscopists have recognised a variety of things, and Ehrenberg has recorded over 200 of the lowest forms of life thus floating in the air. Blackley was one of the first to direct attention to the enormous amount of pollen (the fertilising dust of flowers) to be found in the air, even at considerable elevations, and Maddox has specially directed attention to the innumerable spores (the reproductive seeds) of different forms of fungi.

The evidence of the richness of the air in spores of fungi is before us every day, for if we leave any moist organic matter exposed to the air, we find it "mouldy" after a lapse of a few hours. These "moulds" are in great variety, and differ considerably in colour and "habit," as a gardener would say. Whence came they? The most probable answer is that the spore, or seed, was deposited from the air upon the organic matter, which served as a suitable soil, where the spore quickly reproduced its kind to ripen and give off, in its turn, its thousands or millions of spores to every passing breeze.

The systematic examination of the air is now being carried out in many laboratories, but nowhere more systematically and thoroughly than at the observatory of Mont Souris, in Paris. The work of this observatory is, to some extent, of a novel character, so that I think I shall not do wrong in giving you a sketch of it.

The observatory is under the care of the municipality of Paris, and is situate in the park of Mont Souris, in the extreme south of the city, just within the fortifications. The observatory is under the direction of M. Marié Davey, and its work is divided into three sections, viz.:—

1. Meteorology proper, including magnetic and electrical observations.

2. The chemical analysis of air and rain.

3. The microscopical study of the organic matter suspended in the air, or in the rain and other water collected at the observatory. This department is under the control of M. P. Miquel.

At the close of every year the observatory issues the "Annuaire de Mont Souris," a book full of information, and from which, as well as from Miquel's "Organismes Vivants de l'Atmosphère," much that I am going to say has been derived.

Dr. Miquel has, with regard to the air, made two series of observations, one having reference

to the forms of moulds, fungi, and other lowly organisms, as well as inorganic matter, and the other with reference solely to bacteria and micro-organisms closely allied to them.

Pasteur seems to have been the first to call the attention of the scientific world to the importance of studying the organic matters wafted by the air, and, in 1862, he published a memoir on the subject in the "Annales de Chimie et de Physique." For the next eight years, work in this direction was not very active; but, in 1870, Dr. R. L. Maddox published in the *Monthly Microscopical Journal* the results of a series of experiments made by him with the object of determining the relationship between the organic germs of the atmosphere, and the other meteorological conditions. The main facts established by Dr. Maddox were as follows:—

1. The immense variations which occur in the number of spores floating in the air, variations the extremes of which are represented by the numbers 1 and 250.
2. The small influence which, in the open country, the direction of the wind has upon the number of spores.
3. Their increase in summer, especially (in England) July and August.
4. The velocity of the wind has no constant relation to the number of spores.
5. In very windy weather the inorganic sediments are increased, but there is no increase of spores.
6. Wet weather seems to have the effect of fixing the mineral matters in the soil, but has no similar effect on the spores.

Dr. Maddox found that the spores collected from the air belonged to every form of fungus, and to many forms of lichen. Further, he found portions of green algæ, and a great variety of pollen. Further, Dr. Maddox succeeded in cultivating in suitable liquids many of the spores which he collected.

It was not till 1876 that the systematic observations of air-borne spores was commenced at Mont Souris by Dr. Miquel.

Taking the average of the four years, 1879-82, Dr. Miquel found that each litre of air contained from 12 to 15 spores, and that, in general, they were slightly more abundant during hot years. The effects of season were well marked. Thus in winter there were 6·6 spores per litre of air; in spring, 16·7; in summer, 22·8; in autumn, 10·8.

By means of a most ingenious registering aeroscope, Dr. Miquel has been enabled to observe the hourly fluctuations in the number of spores. This fluctuation is very great indeed, and the causes of it are not always apparent. One fact seems to come out clearly, viz., that a fall of rain has the effect of partially clearing the air of spores for a time.

The causes of the hourly fluctuation are, according to Miquel, mainly two, viz., remote and local. Let us imagine a mass of air travelling from north to south. Coming from regions of ice, and orginally very pure, it strikes a continent, and the mass of air which impinges on the soil makes almost a clean sweep of floating spores, and largely enriches itself at the expense, as it were, of the masses of air following in its wake. Thus the richness in spores diminishes as long as the air blows strictly from one direction.

Among local causes of variation may be mentioned the neighbourhood of great towns or other centres of spore productions.

By means of the registering aeroscope, Miquel has been able to estimate the amount of mineral matters in the air. When the wind blows from the north (*i.e.*, over the City of Paris), at Mont Souris there is a great abundance of inorganic matter and particles of carbon, due to the combustion of fires and the cleaning of the streets, &c. During rain there is an immediate and almost complete disappearance of these matters. Miquel ("Organismes Vivants de l'Atmosphere") warns us that the nature of the particles of dust floating in the air is so varied that one of the first necessities of the experimenter is some sort of classification.

The mineral matter is very varied, carbonaceous, ferruginous, silicious, or cretaceous. These mineral particles may be submitted to chemical tests for the determining of their nature. Sometimes their rough angles and general appearance at once show that they are not organised, but this is not always the case, and since the divisibility of these mineral particles is infinite it is not possible, very often, to distinguish them, by their appearance alone, from micro-organisms of the family of bacteria.

The coarse particles present in the air are not without their use, as they give, as Pouchet said, a character to the whole of the floating matter collected, and enable the observer to say very often whence the air has come. The air of rooms, for example, contains a quantity of coloured textile particles which are seldom met with in the air of the country. In the streets we find in the air the detritus of clothing, but the textile particles are more rare, and are diluted, as it were, with matters of vegetable

and animal origin. In the country, the chief part of the organised matter is formed of vegetable fibres.

The dust of the air is usually collected by exposing a glass slide, previously smeared with some sticky fluid, to the air-current. In making choice of fluid care must be taken that it is not of a character to encourage the growth and multiplication of organic particles, such as the spores of fungi. Miquel asserts that glycerin alone is not suitable, because it attracts water, and then forms a most active cultivating medium. He advises a mixture of glycerin and glucose, which he says is stable, colourless, transparent, and very sticky.

Another difficulty in the examination of the dust of the air is the measuring of the volume of air which passes over the dust traps. Unless this be done, it is evident we get no exact knowledge as to the relative purity or impurity of the air examined. I do not propose to enter into details of the machines for aspirating known quantities of air, but it must suffice to say that at Mont Souris the difficulties of measurement seem to have been completely overcome.

As to matters which are visible with the aid of the microscope, Miquel says, "Apart from the ova of infusoria, whose existence in air-dust is very uncommon, as well as the bacteria, which are indistinguishable among the other matters, we have to deal with:—1. Starch grains. 2. Pollen grains, capable of fertilising other plants of their own species, but incapable of germination. 3. Spores of cryptogams, capable of germinating, and of giving rise to determinate forms of fungi. 4. Complete plants, generally uni-cellular.

Pollen is very common in the spring and summer, and tends to disappear in the autumn and winter. It never completely disappears, even in the winter. In Paris, the amount of pollen found in the air is sometimes very great, and may amount to as much as 5,000 or 10,000 grains per cubic metre.

Spores of cryptogams are the most common of all organic particles found in the air.

Chief Characters of Air-dust.

	Spores.		Pollen.	Mineral.
	Young	Old		
In summer—wet......	Many	Few	Much	Little
,, —dry......	Few	Many	Much	Much
In winter—wet	Few	Few	None	Little
,, —dry	None	Many	Little	Much
In dwellings, &c......	Few	Many	Very few	Very much
In sewers	Many	Few	None	Little

So far we have been considering particles which are comparatively gross—microscopic certainly, but, nevertheless, plainly visible under the microscope, and distinguishable the one from the other by the eye of the expert.

The lower forms of fungi, the so-called schizophytes, which increase almost entirely by the simple process of splitting and dividing, are very much more difficult of detection. Though small, these fungi are by no means to be neglected, for to them belong the bacteria and allied kinds of which we have heard so much of late. These fungi are known to be the cause of some forms of putrefaction, to be the cause of sour milk, rancid butter, ropy beer, &c. They have been found in connection with many most virulent diseases, and are known to be the active cause of some of them. Hence it follows that the study of the bacteria in the air is deemed at present to be of the highest importance. When in small numbers, and when mixed with other matters, they elude the eyes of the most careful investigator, so that recourse must be had to other methods of investigation.

Such a method of investigation is found in what are daily becoming more and more familiar to us, as cultivation experiments.

Of the precautions necessary in conducting such experiments, and of the enormous care and trouble which they involve, I will say nothing; but I will merely state that, in principle, the experiment consists in bringing a measured quantity of air in contact with a putrescible fluid which has been previously sterilised. At Mont Souris, the fluid used is a *bouillon* of beef. It is sterilised by repeated heating, and if, after a month or so, the tube containing the *bouillon* is found to be clear and transparent, and without change, then it is fit for testing the air.

The sterilised tubes are unsealed, a measured quantity of the air to be tested is drawn through them, and they are then re-sealed and kept for several days in a uniform warm temperature. If at the end of this time no change has taken place, then we have no evidence that the portions of air admitted to the tube contained any bacteria; but if the contents of the tube become cloudy and present evidence of bacterial growth, then the portion of air admitted to the tube contained at least one active germ capable of growth. M. Miquel has been in the habit of distributing the air to be examined in a large number of sterilised tubes. For example, he would take 100 litres of air from this room, and inoculate

with it 50 tubes containing sterilised *bouillon*; if, after this, ten of the tubes showed bacterial growth, he would know that his 100 litres of air contained at least ten active bacteria, and he would state the bacterial richness of the air as equal to 100 bacteria per cubic metre.

It must be remembered that this and similar manœuvres have been practised day after day, and sometimes several times a day, at Mont Souris; and I will ask you to think for a moment of the immense labour involved, and of the enormous quantity of material necessary—the thousands of tubes, the gallons of sterilised *bouillon*, and the amount of subsidiary apparatus.

The expense involved in such extensive investigation is not small either, and we cannot but admire the spirited action of the Paris Municipality in establishing this most important observatory.

There are many ways of carrying out the experiments for testing the purity of the air, and in the hands of different workers the details have been much varied.

I propose to show you, with the assistance of my friend, Mr. Joseph Lister, a rough method of treating the purity of the air by means of a potato. I have upon the table two bell-jars and a potato, to which I will invite your attention. We have been at some pains to deprive this potato of all living germs. To this end it has been cleaned, and its outer skin has been washed with a solution of corrosive sublimate, which is about the most powerful antiseptic known. Further, our potato has been subjected to a prolonged steaming, which has thoroughly cooked it. We may assume that the potato has been in this way freed from living germs, or, in other words, that it is sterilised.

We next take one of the bell-jars, and wash its interior with corrosive sublimate solution, so as to kill any germs which may be adhering to it, and further we heat the interior with the flame of a spirit lamp, so as to destroy any living thing that may be in the contained air. Next, we remove the potato from the vessel where it has been steaming, and cut it in halves with a knife, the blade of which has been previously heated in the flame of a spirit lamp. One-half we place under the sterilised bell-jar, the other half we will leave exposed to the air of the room for a few minutes, and then place it under the other bell-jar similarly sterilised. In order to keep the air in the bell-jars moist, we place some blotting paper, moistened with a solution of corrosive sublimate, each. We will now put these potatoes away in a cupboard, and examine them again at the next lecture. We ought to find that the half potato which has been kept sterilised will remain free from growths, while if, as I suppose, the air of this room be charged with living organisms, then we shall find upon the half potato which has been exposed to it centres, more or less numerous, of fungoid and bacterial growth.*

This is but a rough method, no doubt, but it is often of great service. It does not, like the more elaborate method of Miquel, give you anything like an exact quantitive estimate of the richness of the air in living microbes, but it gives a rough idea, and it will serve to give a rough idea to you of the nature of the experiments which are necessary for testing air for bacteria and allied organisms.

I will now bring before you some of the results of Miquel's experiments. Bacteria in the air, like the spores of fungi, are liable to great variations. In the year 1880, there were, on an average, 560 bacteria in each cubic metre of air examined at Mont Souris. In 1881, the average was 590, while in 1882, the figure reached was only 320. In the "Annuaire de Mont Souris" for 1884, M. Miquel gives the weekly average of bacteria found at Mont Souris from January, 1880, to October, 1883. These are given, arranged in parallel columns, with the meteorological data for the same period (barometric pressure, heat, moisture, wind, electricity, ozone, rainfall). From a careful examination of these figures, Miquel has arrived at the opinion that bacteria are apt to increase during periods of high barometric pressure, a rule, however, which is by no means absolute.

Changes of temperature do not produce very sudden changes in the number of bacteria. Sudden increases are, without doubt, most common in summer, but prolonged heat often causes a diminution in the number of microbes. Miquel believes that the thermometer may give the key to certain seasonal variations, but that changes of temperature will not explain the weekly variations.

Bacteria reach their maxima when the hygrometric conditions are feeble, *i.e.*, when the

* These potatoes were examined at the concluding lecture, with the result that the protected potato showed three centres of growth, as against eleven on the potato which had been exposed to the air of the room.

air is dry. This is explained by the fact that moist conditions of atmosphere correspond with times of heavy rain, and when the surface of the ground is sodden, which are always periods of few bacteria in the air.

The direction of the wind has a very decided influence on the number of microbes collected at Mont Souris, which, be it remembered, is situated in the extreme south of Paris. Of thirty maxima (over 600 microbes per cubic metre of air) observed at Mont Souris :—

14	occurred	with the	wind	N.E.
4	,,	,,	,,	N.
4	,,	,,	,,	N.W.
2	,,	,,	,,	W.
5	,,	,,	,,	S.W.
1	,,	,,	,,	E.

With regard to the relationship between ozone and bacteria, Miquel admits that when ozone is in small quantities, bacteria often increase. He gives, however, no credence to the belief which has been put forward by some, that ozone destroys bacteria. The relationship observed between ozone and the number of bacteria is illusory, and is caused by a meteorological condition which is capable at once of producing ozone and lowering the number of microbes. Rain and moisture have, apparently, this double power.

For the year 1882-83, Miquel made calculations for every three days, and comparing the number of bacteria with the rainfall, he came to the conclusion, or rather was confirmed in a conclusion which he had arrived at three years previously that—

"The number of aerial bacteria, which is always slight during times of rain, increases as the drying of the soil progresses, and decreases if the dryness is prolonged beyond a week."

The seasonal changes of bacteria observed at Mont Souris in 1882-83 were as under :—

Autumn	115	microbes per cubic metre.
Winter	115	,, ,,
Spring	550	,, ,,
Summer	?	,, ,,

The enumeration of bacteria was carried on, not only at Mont Souris, but also in the Rue de Rivoli, which is near the centre of the great City of Paris. This work was intrusted to M. Riquet, under the guidance of M. Miquel, and from these researches carried on since January, 1881, the following seasonal averages have been deduced :—

1882-83 (Rue de Rivoli).

Autumn....	2,060	microbes per cubic metre.
Winter	2,040	,, ,,
Spring	1,900	,, ,,
Summer....	3,960	,, ,,
Yearly mean	2,490	,, ,,

Microbes at High Altitudes.—In conjunction with M. Freudenreich, of Berne, M. Miquel investigated the question of the richness in microbes presented by the air of high altitudes. Many investigators have touched this question, but the difficulties of experimenting are very great, and most of the earlier experiments are seriously tainted with error.

The method pursued by Messrs. Miquel and Freudenreich was as follows :—A glass tube was drawn to a point at one end. A plug of spun glass (*coton de verre*) for filtering the air was thrust towards the point, and retained in position by a slight contraction in the tube behind it. A second plug of spun glass was thrust down to the contraction, and then, the point being sealed, the tube was submitted to a temperature of between 200° and 300° C. for some hours. After cooling, the open end is closed with a cork.

The method of conducting the experiment is as follows :—The tube is mounted on a stick, and, the cork being removed, it is placed with its capillary point slightly raised, and facing the wind. An aspirator is then fixed to the open end, and the fine point is removed by means of the blowpipe and a pair of heated forceps. By means of the aspirator, a measured quantity of air is then drawn over the sterilised plug of spun glass. The pointed end is then re-sealed, and the cork replaced. The plugs are then removed, and stirred up with 30 or 40 c. c. of sterilised water, and this water is distributed in any number (ten, twenty, thirty) of flasks of sterilised *bouillon*, which are then kept at a temperature of 30° C. to 35° C. Knowing, on the one hand, the number of successful cultivations in the *bouillon*, and, on the other, the volume of air which had been drawn over the sterilised plug, it is easy to estimate the number of microbes in any known quantity of air.

The following are the details of a few of the experiments carried out by these two enthusiastic observers :—

On July 12, 1883, M. de Freudenreich left Thun, and climbing the Bernese Alps, reached the neighbourhood of the Strahlegg Pass, at an altitude of 3,200 metres, and filtered through

a plug of spun glass (at a height of one metre above the ice) 300 litres of air. A week later he distributed this plug among twelve portions of sterilised *bouillon*. Two and a-half months later, no growth had taken place in the *bouillon*, which remained absolutely limpid.

Three weeks later, two portions of air, of 500 and 400 litres respectively, and taken from altitudes of 2,100 metres and 3,976 metres, were filtered through sterilised plugs, and the plugs were afterwards distributed through portions of *bouillon*, but no growth took place, the *bouillon* remaining perfectly limpid.

In a third experiment, M. de Freudenreich filtered 1,500 litres of air through six plugs on the top of the Schilthorn, at a height of 2,972 metres; the subsequent cultivation experiments gave, as in the other cases, negative results.

"Thus," says M. Miquel, "2,700 litres of air taken from elevations varying from 2,000 to 4,000 metres above sea-level, did not furnish either a bacterium or spore of fungus capable of cultivation and growth in neutralised *bouillon*, a liquid possessing the highest powers of developing schizophytes and fungi; for at the observatory of Mont Souris it is common to see 400 or 600 fungoid spores per cubic metre of air developed in the *bouillon*."

With air taken on the level of the town of Thun, M. de Freudenreich's results were very different. The results may be expressed as follows:—

Bacteria in Ten Cubic Metres of Air.

1. At a height of from 2,000 to 4,000 metres	0·0
2. On the Lake of Thun (560 metres)	8·0
3. Near the Hotel Bellevue, Thun	25·0
4. In a room of the hotel	600·0
5. In the park at Mont Souris............	7600·0
6. In the Rue de Rivoli (Paris)	55000·0

These analyses were all made about the same time—

"In giving these results," says M. Miquel, "I do not pretend to establish, even approximately, the comparative richness in microbes of the air of Switzerland and Paris. In order to firmly establish such a fact, a prolonged series of experiments would be necessary. But the above results enable us to conclude forthwith that the air of the Valley of Thun is very poor in germs. The objections might be made that I had allowed my air-dust to remain eight or ten days on the filter plugs prior to the attempts at cultivation. This might have the effect of lowering the number of bacteria, because some of the germs might die in the interval of falling on the cotton, and subsequent immersion in the *bouillon*. But this supposition cannot constitute a serious objection, for experiments show that the tenderest bacteria will resist five or six months drying, and that micro-cocci preserve the faculty of reproduction for years."

The diminution of microbes in the air of the Swiss mountains seems to Miquel to be due—

1. To the diminution of atmospheric pressure. At a height of 4,000 metres, a volume of air from the plain would occupy twice its original space, and thus the atmospheric dust is diluted.

2. To the lessened density of the air, which becomes less and less able to hold solid bodies in suspension.

3. To the progressive disappearance of the productive foci of bacteria. At the snow-line the disappearance of these foci is absolute.

To give an idea of how the atmospheric purity increases as we rise perpendicularly above the sources of microbes and infecting particles, Miquel mentions the result of two analyses of air obtained simultaneously; the one in the Rue de Rivoli, and the other from the top of the Pantheon, the difference in elevation being 100 metres. At the lantern of the Pantheon the air is twenty times more pure than at the Mairie of the 4th arrondissement, situate in the Rue de Rivoli.

Many other reasons for the rarity of germs at high altitudes might be invoked. Among these the cold is not without influence, although the power of cold to kill microbes has always seemed to M. Miquel to be feeble. In December, 1879, Miquel submitted some sealed tubes containing bacteria in distilled water to a temperature of —7° C. for twenty days, and subsequently to a temperature of —30° C., but without destroying the vitality of the bacteria. In 1881, a director of the Swiss Ice Company sent to M. Miquel a block of ice eleven months old, weighing 50 kilogrammes, and which had been taken from the Valley of Joux. In three samples taken from the centre of this block M. Miquel found examples of a micrococcus of the nature of sarcina, and he calculated that this block contained 780,000 bacteria which were still alive.

In December, 1882, by the kindness of Prof. Raoul Pictet, of Geneva, M. Miquel was enabled to submit some of his tubes containing bacteria to a temperature of — 100° C., and in this experiment it was found that many bacteria which are unable to resist a temperature of 70° C. for two hours were able to withstand this degree of cold. One fact was noticeable,

viz., that some of the bacteria had "grown old," as Miquel puts it, and when they were sown in nutritive liquids, growth was delayed for three days, instead of being observable at the end of twenty-four hours, as is usually the case.

M. Miquel's researches on the air of the wards of hospitals were carried out at the Hotel Dieu and the Hospital Notre Dame de la Pitié, and with the result, that for the whole year the hospital air contained on an average 11,100 bacteria per cubic metre, as against 850 bacteria per cubic metre in the air of the Rue de Rivoli.

Taking the whole year through, it was found that the increase and decrease of bacteria in the air of hospital wards obeyed laws very different from those observed in the open air. The hospital bacteria, in fact, reached their minimum at the time when the windows could be kept open, *i.e.*, in June, July, and August, when the numbers fell to about half of the average, viz., 5,500, at a time when the bacteria in the street had attained a maximum of about 1,300, or 50 per cent. in excess of the average. The maximum of the hospital (28,000) was reached in January, when the weather was cold and the windows shut, and the average in the street had fallen to 160.

Reflecting on this curious and interesting result of his inquiry, M. Miquel says :—"If hospitals be built in the middle of cities, the surrounding quarters must receive microbes which possibly are not always harmless," and he quotes M. Bertillon in support of his proposition. M. Bertillon says :—

"I wish to point out the lessening week by week, and the final cessation on the 17th week of this year, 1880, of deaths from small-pox in the quarters of the Sorbonne, which was so exceptionally smitten by the malady in January, February, and March, for the diminution no less than the aggravation will serve to show the cause of the ravages. By referring each case of small-pox to the house in which it had originated, we found them grouped round the annex of the Hotel Dieu, as round an epidemic centre squeezed in between the Seine and the Boulevard St. Germain. In this district, with 10,000 inhabitants, there were forty-nine deaths from small-pox in January and February, notwithstanding that its due proportion, having regard to the population and the intensity of the epidemic, would have been three. How are these forty-six deaths in excess of the average for the rest of the city to be accounted for, except by the fact that the annexe of the Hotel Dieu, around which the stricken houses were situated, had at the time been made a depôt for small-pox cases, whither they were all sent for the laudable purpose of isolation. This measure seems to have changed the mode of transmission rather than to have suppressed it, and the small-pox, instead of going from bed to bed, spread from house to house round the variolous centre, and now that the depôt had been closed, the small-pox is disappearing."

The annex of the Hotel Dieu being closed, the small-pox patients were sent to another hospital, and M. Bertillon says :—

"Attention is directed to the ravages of small-pox in the quarter of Quinze Vingts, and the neighbourhood of Sainte Marguerite and La Roquette. These districts continue to register three or four times their due amount of small-pox. These ravages are but too easily explained by the presence of the St. Antoine Small-pox Hospital, which has replaced the annex of the Hotel Dieu. During the first three months of the year the hospital contained 100 small-pox patients, and thus the contagion with which the annex of the Hotel Dieu was poisoning the Sorbonne were moved to these quarters. The contagion was imported with the patients by the administration, who thus furnished an experimental proof of our former conclusions."

M. Miquel's examination of dust and soil shows that these swarm with bacteria, and that, as regards dust deposited on free surfaces, it contained bacteria unproportional to the richness, in that respect, of the air whence the dust was deposited.

The Mont Souris experiments clearly show that the number of living organisms in the air are in direct proportion to the density of population. On mountain solitudes they are fewest; at points elevated above crowded cities they are comparatively scarce; at the Park of Mont Souris, on the outskirts of Paris, they are far less numerous than in the centre of Paris, as in the Rue de Rivoli; and the numbers in the Rue de Rivoli, large as they are, become insignificant when compared with the quantity detected in the air of crowded dwellings and of hospitals. We have seen that in crowded cities, and still more in crowded rooms and homes, carbonic acid is present in the air in greater or less extent, and we have come to the conclusion that the carbonic acid *per se* is probably not very harmful, but that carbonic acid always comes in bad company, especially in the company of organic matter, which gives the close organic smell to crowded places. Part, at least, of the organic matter is, we now know, composed of micro-organisms, such as micro-cocci, bacteria, and bacilli.

Why should we attach so much importance

to these micro-organisms? There are a great variety of them, and the differences of their appearances are so slight that by the eye alone, even when aided by the highest powers of the microscope, it is impossible to distinguish many of them apart. Many of them play a part in the economy of nature which we must all recognise as of the highest importance. They are the great agents of putrefaction and decay; they are the active cause, as it were, of the breaking up of effete organic matter into its simple chemical elements. They are essential for the complete round of changes which we see going on around us. The animals prey upon each other, and on plants. The plants live on organic refuse, both animal and vegetable, but before organic refuse can become fit food for the higher plants, it becomes the prey of those low vegetable organisms which are the cause of putrefaction and decay, and which are to be found in the air, the water, and the soil, ready at all times to perform their mission.

It used to be thought that in order to stop putrefaction and decay, the "exclusion of the air" was, before all things, necessary. It has of late years been proved that the gases of the air are powerless, of themselves, to produce putrefaction, decay, or the allied process of fermentation; and that if the air be freed from micro-organisms, putrescible matter will remain unchanged for months or years. When an organic body ferments, or putrefies, then things happen which cannot but demand our attention. These are—(*a*) the giving off of gas which is mainly carbonic acid, but which may be mixed with other offensive smelling gases; (*b*) the multiplication of the organism which is the cause of the ferment, so that the fermenting or putrefying mass becomes a focus for the dissemination of the organism; (*c*) a chemical change in the fermentible body. During vinous fermentation, alcohol is formed; and during some forms of putrefaction, bodies of the nature of alkaloids are formed which are actively and quickly poisonous.

Ordinary putrefaction has long been recognised as an occasional danger to health, and irritant poisoning from eating putrid food is no very rare occurrence. What is known as "antiseptic surgery," which we owe to the genius of Sir Joseph Lister, consists in measures calculated to prevent putrefaction in wounds, whether the result of accident or the surgeon's knife. The putrefying of the wound is the cause of blood poisoning and death, and it is now known that if a wound can be kept sweet, it is hardly a source of danger to the patient, no matter what its extent may be. A putrefying wound may cause death in two ways—(1) by the entrance of the organism into the blood of the patient, and its subsequent growth in his body; and (2) by the absorption of the poison which is formed during putrefaction. In the former case death is gradual, and in the latter case it is sudden.

By the skill of experimenters, many of the micro-organisms have been differentiated and propagated by pure cultivation in fluids and semi-solids of a suitable constitution, and in this way, assisted by other methods of experiment, it has been shown that particular organisms are invariably associated with certain diseases, and that in some cases the organism is the veritable cause of the disease.

Thus it may be considered as proved beyond doubt that erysipelas is due to the growth of a micrococcus in the skin, and that splenic fever of cattle is due to the growth of a bacillus in the blood. Definite micro-organisms have been discovered to be inseparably connected with tubercular disease, pneumonia, glanders, relapsing fever, ague, typhoid fever, and it is only a matter of fair inference that if the case is proved in regard to a large number of these infective or zymotic diseases, a similar basis of causation will be found in connection with the others.

Since micro-organisms are found to be definitely connected with disease, and since micro-organisms are found not only in the soil and water, but may be raised by the wind and transported any distance, the study of these organisms in the air is of prime importance from the point of view of health.

Now the conditions of growth of these organisms have been studied with great care, and it is found that they only grow and flourish under certain conditions. The most important condition is a suitable amount of warmth and moisture. The most favourable temperature seems to be, broadly speaking, between 60° Fah. and 100° Fah. Cold checks their growth, as likewise do high temperatures.

We know how putrefactive changes run riot when the weather is warm and moist, and the history of cholera, plague, and yellow fever show what may be the ravages of zymotic disease in tropical climates; and the recent researches into the life history of micro-organisms makes it impossible for us not to see the strongest analogy between the two conditions.

While the evidence that many diseases which affect the human race are caused by the growth of parasitical fungi in the tissues of our bodies is so strong, and is gathering strength so fast as to be almost unanswerable, we have to remember that for the growth of a micro-organism to produce disease, just as for the growth of a food-plant, something more is necessary than spore or seed, moisture or temperature.

That something is a suitable soil. All agriculturists know that very small differences in soils make very great differences in the growth of plants. In one field we may have a stunted crop choked by weeds, and a prey to parasites, while in the next field we may have the same plant showing a vigorous and healthy crop, a crop whose very vigour makes it difficult for weeds to flourish. On inquiry, we may find that the soil of the two fields was originally the same, but that the addition of a small quantity of suitable manure, ammonia, nitrates, phosphates, potash, lime, or what not, has caused a vigorous growth in the one case, while the want of it has prevented vigorous growth in the other case. This is an every day experience.

Messrs. Lawes and Gilbert have, for years past, been making most valuable experiments on the effects of different manurial bodies. With crops which take six or eight months to come to perfection, experiment is but a slow method of gaining knowledge; and it is evident that experiments made in the field must lack much of the exactness which is obtainable in the laboratory.

In Dr. Duclaux's admirable little work on "Fermentation," which was written at the request of the Council of the recent Health Exhibition, will be found an account of some experiments carried out by M. Raulin.

M. Raulin devoted his attention to one of the commonest mould fungi, the *Aspergillus niger*. The spores of this fungus, when sown in a suitable soil, soon produce a mass of white branching threads, the so-called mycelium; and then there appear the spore-bearing filaments, whose black *capitula* make the mass look like velvet. This fungus grows readily on pieces of bread moistened with vinegar, or on slices of lemon, and generally on acid fruits and liquids.

By a series of experiments, however, M. Raulin devised a liquid in which the *aspergillus* grew with the greatest uniformity, so that crops of the fungus grown on equal quantities and areas of the liquid differed from each other only to the extent of 5 per cent. The composition of Raulin's liquid for the growth of the *aspergillus* is as follows:—

	Grammes.
Water	1,500·00
Sugar candy	70·00
Tartaric acid	4·00
Nitrate of ammonia	4·00
Phosphate ,,	0·60
Carbonate of potassium	0·60
,, magnesium	0·40
Sulphate of ammonia	0·25
,, zinc	0·07
,, iron	0·07
Silicate of potassium	0·07

The growth requires free exposure to the air, as the fungus needs a good supply of oxygen. A temperature of nearly 35° C. is found to be most favourable to it; and it grows best when the liquid is spread in a layer of two to three centimetres of depth over a shallow porcelain dish. If under these conditions the spores be sown, we find in twenty-four hours that the liquid is covered with a white layer of mycelium; the fructification begins, and in three days the cycle of changes is complete, and the crop is ripe. The first crop is removed, and more spores are sown, and at the end of three days there is a second crop. The two crops are then dried, and are found to weigh twenty-five grammes, and the nutritive liquid is exhausted.

Here, then, is an experiment on manures and soils which is complete in six days, and which is so manageable that thousands of experiments might be perfected within a year. Further, it has all the elements of exactness and precision.

Now the growth of a plant is a struggle between it and other organisms. All organisms have their enemies and their parasites, and must destroy them or be destroyed by them. The *aspergillus* is no exception, but in Raulin's liquid it flourishes, and none of its enemies get ahead. The *aspergillus* is stronger than its enemies, because it finds in Raulin's liquid all the elements which it requires. If one of these elements were to fail it would still live, but with difficulty, and its power of resistance would diminish. If several were to fail, then it would dwindle, fade, and make way for a neighbouring species of a less exacting nature, or having other requirements more easily fulfilled in a medium which has become a poor one for the *aspergillus*, but a rich one perhaps for the other species.

M. Raulin made comparative experiments, growing the plant (a) in the complete liquid, and (b) in the liquid minus one or other of its constituents. Here are some of his results:—

			Grammes.
1.	With the liquid complete	....	25·000
2.	,,	minus potassium	1·000
3.	,,	,, phosphoric acid	0·125
4.	,,	,, ammonia......	0·002
5.	,,	,, the zinc	2·005

The effect of the withdrawal of the zinc is most remarkable, when we consider that in the 7 milligrammes of the sulphate there are but 3·2 milligrammes of zinc, constituting the $\frac{1}{50000}$ part of the fluid. The action of such a minute quantity of metal represents an increase of 22·5 grammes to the crop, *i.e.*, a weight of plant equal to 700 times its own weight.

Further, it has been stated that the $\frac{1}{1600000}$ part of nitrate of silver stops the growth altogether, and so sensitive is the plant to the action of silver, that the growth will not even commence in a silver vase. The growth is similarly stopped by $\frac{1}{500000}$ part of corrosive sublimate, by $\frac{1}{8000}$ of bichloride of platinum, and $\frac{1}{240}$ of sulphate of copper.

The withdrawal of iron from the liquid produces results similar to the withdrawal of zinc, while the addition of 1 gramme of iron to the liquid will increase the crop by 800 grammes. Notwithstanding this, the functions of the zinc and iron are quite different. Zinc enters the plant as one of its constituent elements, iron does not. The use of the iron is said to be to destroy or suppress, pending production, a poison which the plant secretes, and which, were it to accumulate, would end by killing the plant.

These experiments of Raulin's are most instructive, as showing us what apparently insignificant trifles may cause an organism to flourish or languish. Many of the micro-organisms connected with disease are cultivated with ease in artificial media, while the attempt to cultivate others has proved unsuccessful. This want of success is not to be wondered at, when we consider the effect of $\frac{1}{1600000}$ part of nitrate of silver in checking the growth of the *Aspergillus niger*.

The effect of the minimal quantities of certain ingredients in "soils" (using the word as signifying all propagating media) enables us to frame an hypothesis for the explanation of certain phenomena connected with disease. Why is it, for example, that many of the zymotic diseases only occur, as a rule, once in a lifetime, and that one attack is preventive of subsequent attacks? This strange phenomenon is readily explained, if we may assume that the micro-organism or zyme, by its growth, deprives the blood or the tissues of some ingredient (absolutely insignificant) without which the disease germs cannot flourish.

If, after the lapse of time, this hypothetical ingredient re-accumulates, then the body is ripe for a second attack of the malady. In like manner the effect of minimals on the growth of organisms may afford an explanation of why it is that zymotic diseases become epidemic, why at one time they involve a small area, and at another time a large area, and yet the cause may elude our coarse vision. In the old days, when it was the fashion to inoculate for the small-pox, the inoculated disease was generally milder and less dangerous than the disease contracted in the ordinary way, the reason being probably that when the disease was inoculated the patient's body was not in the highest state of efficiency for growing small-pox, if such an expression may be used.

The effect of minimals on the growth of organisms may afford an explanation of why it is that some diseases seem to flourish more in some families than in others. Why, for example, does scarlet fever fall heavily on some families for successive generations; and how comes it that consumption, which is almost certainly dependent on an organism, is so clearly hereditary? If we may assume that what is known as "family constitution" is an aptness on the part of the blood and tissues to grow this or that organism, the explanation is easy.

Seeing how omnipresent are the micrococci, bacteria, and bacilli, of which we have been speaking, how they infest the air, the soil, the water; and seeing again that it is an undoubted fact that the organisms of disease may live and grow in suitable putrescible liquids outside the human body, it is almost a matter of surprise that we are any of us alive to discuss the question. From what we have been saying, however, it appears that for the flourishing of infective organisms three things are necessary, in addition to the organism, viz., some degree of warmth, a suitable condition of moisture, and a "soil" apt to grow the organism. It is when we get the coincidence of all the conditions that we get the disease in its marked form. The cold of the Arctic winter seems to be sufficient to prevent putrefaction, and to prevent the spread of many of the zymotic

diseases. In tropical countries, where putrefaction flourishes, zymotics flourish, and if we want to enjoy health in hot countries we must exercise the greatest care and circumspection in dealing with all putrescible matters, whether excremental or otherwise; finally, it is only unhealthy persons who become a prey to parasites, and a healthy man is probably more than a match for most of the so-called pathological organisms.

LECTURE III.—Delivered January 26, 1885.

DISEASES CAUSED BY FLOATING MATTER IN THE AIR.—MALARIA.—MOUNTAIN CLIMATE.—CONCLUSION.

The information which modern methods of research have given us with regard to the floating matter in the air, is of an importance which cannot be over-estimated.

That the air is full of organic particles capable of life and growth is now a matter of absolute certainty. It has long been a matter of speculation, but there is a great difference between a fact and a speculation. An eminent historian has recently deprecated the distinction which is conventionally drawn between science and knowledge, but, nevertheless, such a distinction is useful, and will continue to be drawn. A man's head may be filled with various things. His inclination may lead him, for example, to study archaic myths in the various dialects which first gave them birth; he may have a fancy for committing to memory the writings of authors on astrology, or the speculations of ancient philosophers, from Aristotle and Lucretius downwards. Such a one may have a just claim to be considered a man of learning, and far be it from me to despise the branches of knowledge towards which his mind has a natural bent. But in so far as his knowledge is a knowledge of fancies rather than facts, it has no claim to be called science. Fancies, however beautiful, cannot form a solid basis for action or conduct, whereas a scientific fact does. It is all very well to suppose that such and such things may be, but mere possibilities, or even probabilities, do not breed a living faith. They often foster schism, and give rise to disunited or opposed action on the part of those who think that such and such things may not be. When, however, a fancy or a speculation becomes a fact which is capable of demonstration, its universal acceptance is only a matter of time, and the man who neglects such facts in regulating his actions or conduct is rightly regarded as insane all the world over. The influence of micro-organisms on disease is emerging more and more, day by day, from the regions of uncertainty, and what once were the speculations of the few are now the accepted facts of the majority.

Miquel's experiments show very clearly that the number of microbes in the air corresponds with tolerable closeness to the density of population. From the Alpine solitudes of the Bernese Oberland to the crowded ward of a Parisian hospital, we have a constantly ascending ratio of microbes in the air, from zero to 28,000 per cubic metre. Their complete absence on the Alps is mainly due to the absence of productive foci. Organic matter capable of nourishing microbes is rare, and the dryness and cold prevent any manifestation of vitality or increase. Whence come the large number of microbes in the crowded places and in hospitals? Every individual, even in health, is a productive focus for microbes; they are found in the breath, and flourish luxuriantly in the mouth of those especially who are negligent in the use of the tooth brush. When we speak of "flourishing luxuriantly," what do we mean? Simply that these microbes, under

favourable circumstances, increase by simple division, and that one becomes about 16,000,000 in twenty-four hours. The breath, even of healthy persons, contains ammonia and organic matter which we can smell. When the moisture of the breath is condensed and collected it will putrefy. Every drop of condensed moisture that forms on the walls of a crowded room is potentially a productive focus for microbes. Every deposit of dirt on persons, clothing, or furniture, is also a productive focus, and production is fostered in close apartments by the warmth and moisture of the place. In hospitals productive foci are more numerous than in ordinary dwellings. If microbes are present in the breath of ordinary individuals, what can we expect in the breath of those whose lungs are rotten with tubercular disease? Then we have the collections of expectorated matter and of other organic secretions, which all serve as productive foci. Every wound and sore, when antiseptic precautions are not used, becomes a most active and dangerous focus, and every patient suffering from an infective disease is probably a focus for the production of infective particles. When we consider, also, that hospital wards are occupied day and night, and continuously for weeks, it is not to be wondered at that microbes are abundant therein.

I want also especially to dwell upon the fact that foci, and probably productive foci, may exist outside the body. It is highly probable, judging from the results of experiments, that every collection of putrescible matter is potentially a productive focus of microbes. The thought of a pit, cesspool, or sewer filled with excremental matters mixed with water, seething and bubbling in its dark warm atmosphere, and communicating directly (with or without the intervention of that treacherous machine called a trap) with a house, is enough to make one shudder, and the long bills of mortality already chargeable to this arrangement tell us that if we shudder we do not do so without cause. As an instance of the way in which dangers may work in unsuspected ways, I may mention the fact that Emmerich, in examining the soil beneath a ward of a hospital at Amberg, discovered therein the peculiar micrococcus which causes pneumonia, and which had probably been the cause of an outbreak of pneumonia that had occurred in that very ward.

The importance of "Dutch cleanliness" in our houses, and the abolition of all collections of putrescible matter in and around our houses, is abundantly evident.

It will not be without profit to examine some well-known facts, by the aids of the additional light which has been thrown upon them by the study of the microbes which are in the media around us.

There is no better known cause of a high death-rate than overcrowding. Overcrowding increases the death-rate from infectious diseases, especially such as whooping cough, measles, scarlet fever, diphtheria, small-pox, and typhus. The infection of all these diseases is communicable through the air, and where there is overcrowding, the chance of being infected by infective particles, given off by the breath or skin, is of course very great. Where there is overcrowding, the collections of putrescible filth are multiplied, and with them probably the productive foci of infective particles. Tubercular disease, common sore throat, chicken-pox, and mumps, are also among the diseases which are increased by overcrowding.

To come to details which are more specific, let us consider the case of some diseases which are definitely caused by floating matter in the air. First, let us take one which is apparently attributable to pollen.

Hay-fever.

Among diseases which are undoubtedly caused by floating matter in the air, must be reckoned the well-known malady "hay-fever," which is a veritable scourge during the summer months to a certain per-centage of persons, who have, probably, a peculiarly sensitive organisation to begin with, and are, in a scientific sense, "irritable."

This disease has been most thoroughly and laboriously investigated by Mr. Charles Blackley, of Manchester, who, being himself a martyr to hay-fever, spent ten years in investigating the subject, and published the result in 1873, in a small work entitled "Experimental Researches on the Causes and Nature of *Catarrhus æstivus* (hay-fever or hay-asthma)."

Mr. Blackley had little difficulty in determining that the cause of his trouble was the pollen of grasses and flowers, and his investigations showed that the pollen of some plants was far more irritating than the pollen of others. The pollen of rye, for example, produced very severe symptoms of catarrh and asthma, when inhaled by the nose or mouth. Mr. Blackley came to the conclusion that the action of the pollen was partly chemical and partly mechanical, and that the full effect was not produced until the outer envelope burst

and allowed of the escape of the granular contents.

Having satisfied himself that pollen was capable of producing all the symptoms of hay-fever, Mr. Blackley next sought to determine, by a series of experiments, the quantity of pollen found floating in the atmosphere during the prevalence of hay-fever, and its relation to the intensity of the symptoms. The amount of pollen was determined by exposing slips of glass, each having an area of a square centimetre, and coated with a sticky mixture of glycerine, water, proof spirit, and a little carbolic acid. Mr. Blackley gives two tables, showing the average number of pollen grains collected in twenty-four hours on one square of glass, between May 28th and August 21st, in both a rural and an urban position. The maximum both in town and country was reached on June 28th, when in the town 105 pollen grains were deposited, and in the country 880 grains. The number of grains deposited was found to vary much, falling almost to zero during heavy rain, and rising to a maximum if the rain were followed by bright sunshine. Mr. Blackley found that the severity of his own symptoms closely corresponded to the number of pollen grains deposited on his glasses. Mr. Blackley also devised some very ingenious experiments to determine the number of grains floating in the air at different altitudes. The experiments were conducted by means of a kite, to which the slips of glass were attached, fixed in an ingenious apparatus, by means of which the surface of the glass was kept covered until a considerable altitude had been reached. Mr. Blackley's first experiment gave as a result that 104 pollen grains were deposited in the glass attached to the kite, while only 10 were deposited on a glass near the ground. This experiment was repeated. Again and again, and always with the same result, there was more pollen in the upper strata of the air than in the lower.

A very interesting experiment was performed at Filey, in June 1870. A breeze was blowing from the sea, and had been blowing for 12 or 15 hours. Mr. Blackley flew his kite to an elevation of 1,000 feet. The glass attached to the kite was exposed for three hours, and on it there were 80 grains of pollen, whereas a similar glass, exposed at the margin of the water, showed no pollen nor any organic form. Whence came this pollen collected on the upper glass? Probably from Holland or Denmark. Possibly from some point nearer the centre of Europe.

Potato Disease.

A study of the terrible disease which so often attacks the potato crop in this country will serve, I think, to bring forcibly before you certain untoward conditions which may be called climatic, and which are attributable to fungoid spores in the air.

With the potato disease you are all, probably, more or less practically acquainted. When summer is at its height, and when the gardeners and farmers are all looking anxiously to the progress of their crops, how often have we heard the congratulatory remark of "How well and strong those potatoes look." Such a remark is most common at the end of July or the beginning of August, when the green part, or haulm, of the plant is looking its best, and when the rows of potatoes, with their elegant rich foliage and bunches of blossom, have an appearance which would almost merit their admission to the flower border. The same evening, it may be, there comes a prolonged thunder storm, followed by a period of hot, close, moist, muggy weather. Four-and-twenty hours later, the hapless gardener notices that certain of his potato plants have dark spots upon some of their leaves. This, he knows too well, is the "plague spot," and if he examine his plants carefully he will perhaps find that there is scarcely a plant which is not spotted. If the thunder shower which we have imagined be followed by a long period of drought, the plague may be stayed and the potatoes saved; but if the damp weather continue, the number of spotted leaves among the potatoes increases day by day, until the spotted leaves are the majority; and then the haulm dies, gets slimy, and emits a characteristic odour; and it will be found that the tubers beneath the soil are but half developed, and impregnated with the disease to an extent which destroys their value.

Now the essential cause of the potato disease is perfectly well understood. It is parasitical, the parasite being a fungus, the *Peronospora infestans*, which grows at the expense of the leaves, stems, and tubers of the plant until it destroys their vitality. If a diseased potato leaf be examined with the naked eye, it will be seen that, on the upper surface, there is an irregular brownish black spot, and if the under surface of the leaf be looked at carefully, the brown spot is also visible, but it will

be seen to be covered with a very faint white bloom, due to the growth of the fungus from the microscopic openings or "stomata," which exist in large numbers on the under surface of most green leaves. The microscope shows this "bloom" to be due to the protrusion of the fungus in the manner stated, and on the free ends of the minute branches are developed tiny egg-shaped vessels, called "conidia," in which are developed countless "spores," each one of which is theoretically capable of infecting neighbouring plants.

Now it is right to say that, with respect to the mode of spread of the disease, scientific men are not quite agreed. All admit that it may be conveyed by contact, that one leaf may infect its neighbours, and that birds, flies, rabbits, and other ground game, may carry the disease from one plant to another and from one crop to another. This is insufficient to account for the sudden onset and the wide extent of potato "epidemics," which usually attack whole districts at "one fell swoop." Some of those best qualified to judge believe that the spores are carried through the air, and I am myself inclined to trust in the opinion expressed by Mr. William Carruthers, F.R.S., before the Select Committee on the Potato Crop in 1880. Mr. Carruthers' great scientific attainments, and his position as the head of the Botanical Department of the British Museum, and as the Consulting Naturalist of the Royal Agricultural Society, at least demand that his opinion should be received with the greatest respect and consideration. Mr. Carruthers said (Report on the Potato Crop, presented to the House of Commons, July 9, 1880, Question 143, *et seq.*) :—

"The disease, I believe, did not exist at all in Europe before 1844. . . . Many diseases had been observed; many injuries to potatoes had been observed and carefully described before 1844; but this particular disease had not. It is due to a species of plant, and although that species is small, it is as easily separated from allied plants as species of flowering plants can be separated from each other. This plant was known in South America before it made its appearance in this country. It has been traced from South America to North America, and to Australia, and it made its first appearance in Europe, in Belgium, in 1844, and within a very few days after it appeared in Belgium it was noticed in the Isle of Wight, and then within almost a few hours after that it spread over the whole of the south of England and over Scotland. . . . When the disease begins to make its appearance the fungus produces these large oblong bodies (*conidia*), and the question is how these bodies are spread, and the disease scattered. . . . I believe that these bodies which are produced in immense quantities, and very speedily, within a very few hours after the disease attacks the potato, are floated in the atmosphere, and are easily transplanted by the wind all over the country. I believe this is the explanation of the spread of the disease in 1844, when it made its appearance in Belgium. The spores produced in myriads were brought over in the wind, and first attacked the potato crops in the Isle of Wight, and then spread over the south of England. The course of the disease is clearly traced from the south of England towards the midland counties, and all over the island, and into Scotland and Ireland. It was a progress northwards. . . . This plant, the *Peronospora infestans*, will only grow on the *Solanum tuberosum*, that is the cultivated potato. . . . Just as plants of higher organisation choose their soils, some growing in the water, and some on land, so the *Peronospora infestans* chooses its host plant; and its soil is this species the *Solanum tuberosum*. It will not grow if it falls on the leaves of the oak or the beech, or on grass, because that is not its soil, so to speak. Now the process of growth is simply this. When the conidia fall on the leaf, they remain there perfectly innocent and harmless unless they get a supply of water to enable them to germinate. . . . The disease makes its appearance in the end of July, or the beginning of August, when we have, generally, very hot weather. The temperature of the atmosphere is very high, and we have heavy showers of rain."

The warmth and moisture are, in fact, the conditions necessary for the germination of the conidia. Their contents (zoospores) are liberated, and quickly grow in the leaf, and soon permeate every tissue of the plant.

It was clearly established before the committee that not all potatoes were equally liable to the disease. The liability depends upon strength of constitution. It is well known that potatoes are usually, almost invariably, propagated by "sets," that is, by planting tubers, or portions of tubers, and this method of propagation is analogous to the propagation of other forms of plants by means of "cuttings." When potatoes are raised from seed, it is found that some of the "seedlings" present a strength of constitution which enables them to resist the disease for some years, even though the subsequent propagation of the seedling is entirely from "sets." The raising of seedling potatoes is a tedious process, but the patience of the grower is often rewarded by success, and I may allude to the fact that the so-called "Champion

potato," raised from seed in the first instance by Mr. Nicoll, in Forfarshire, and since propagated all over the country, has enjoyed, deservedly as it would appear, a great reputation as a disease-resisting potato; but all who have a practical knowledge of potato-growing seem agreed that we cannot expect its disease-resisting quality to last at most more than twenty years from its first introduction (in 1877), and that in time the constitution of the "Champions" will deteriorate, and it will become a prey to disease.

There is some evidence to show, also, that the constitution of the potato may be materially influenced by good or bad culture. Damp soils, insufficient or badly-selected manures, the selection of ill-developed potatoes for seed, and the overcrowding of the "sets" in the soil, all seem to act as causes which predispose the potatoes to the attacks of the parasite. Strong potatoes resist disease just as strong children will; while weak potatoes, equally with weak children, are liable to succumb to epidemic influences.

The following account of some exact experiments carried out by Mr. George Murray, of the Botanical Department of the British Museum, seems to show that Mr. Carruthers' theory as to the diffusion of conidia through the air is something more than a speculation:—

"In the middle of August, 1876," says Mr. Murray, "I instituted the following experiments, with the object of determining the mode of diffusion of the conidia of *Peronospora infestans*.

"The method of procedure was to expose on the lee side of a field of potatoes, of which only about 2 per cent. were diseased, ordinary microscopic slides, measuring 2 in. long by 1 in. broad, coated on the exposed surface with a thin layer of glycerine, to which objects alighting would adhere, and in which, if of the nature of conidia, they would be preserved. These slides were placed on the projecting stones of a dry stone wall which surrounded the field, and was at least five yards from the nearest potato plant. During the five days and nights of the experiment, a gentle wind blew, and the weather was, on the whole, dry and clear. Every morning, about nine o'clock, I placed fourteen slides on the lee side of the field, and every evening, about seven o'clock, I removed them, and placed others till the following morning at nine o'clock. The fourteen slides exposed during the day, when examined in the evening, showed (among other objects)—

"On the first day........	15	conidia.
" second day	17	"
" third day	27	"
" fourth day......	4	"
" fifth day	9	"

"On none of the five nights did a single conidium alight on the slides. This seemed to me to prove that during the day the conidia, through the dryness of the atmosphere and the shaking of the leaves, became detached and wafted by the air; while during the night the moisture (in the form of dew, and on one occasion of a slight and gently falling shower), prevented the drying of the conidia, and thus rendered them less easy of detachment.

"I determined the nature of the conidia—(1) by comparing them with authentic conidia directly removed from diseased plants; (2) by there being attached to some of them portions of the characteristic conidiaphores; and (3) by cultivating them in a moist chamber, the result of which was, that five conidia, not having been immersed in the glycerine, retained their vitality, which they showed by bursting and producing zoospores in the manner characteristic of *Peronospora infestans*."

Influenza.

Let us look at another disease by the light of recent knowledge, viz., the epidemic influenza, concerning which I remember hearing much talk, as a child, in 1847-48. There has been no epidemic of this disease in the British Isles since 1847, but we may judge of its serious nature from the computation of Peacock that, in London alone, 250,000 persons were stricken down with it in the space of a few days. It is characteristic of this disease that it invades a whole city, or even a whole country at once, resembling in its sudden onset and its extent the potato disease which we have been considering. The mode of its spreading forbids us to attribute it, at least in any material degree, although it may be partially so, to contagion in the ordinary sense, *i.e.*, contagion passing from person to person along the lines of human intercourse. It forbids us also to look at community of water supply or food, or the peculiarities of soil, for the source of the disease virus. We look, naturally, to some atmospheric condition for the explanation. That the atmosphere is the source of the virus is made more likely from the fact that the disease has broken out on board ship in a remarkable way. In 1782, there was an epidemic, and on May 2nd, in that year, says Sir Thomas Watson—

"Admiral Kempenfelt sailed from Spithead with a squadron, of which the *Goliah* was one. The crew of that vessel were attacked with influenza on May 29th, and the rest were at different times affected and so many of the men were rendered incapable of duty by this prevailing sickness, that the whole squadron was obliged to return into port about the

second week in June, not having had communication with any port, but having cruised solely between Brest and the Lizard. In the beginning of the same month another large squadron sailed, all in perfect health, under Lord Howe's command, for the Dutch coast. Towards the end of the month, just at the time, therefore, when the *Goliah* became full of the disease, it appeared in the *Rippon*, the *Princess Amelia*, and other ships of the last-mentioned fleet, although there had been no intercourse with the land."

Similar events were noticed during the epidemic of 1833—

"On April 3rd, 1833—the very day on which I saw the first two cases that I did see of influenza, all London being smitten with it on that and the following day—the *Stag* was coming up the Channel, and arrived at two o'clock off Berry Head on the coast of Devonshire, all on board being at that time well. In half an-hour afterwards, the breeze being easterly and blowing off the land, 40 men were down with the influenza, by six o'clock the number was increased to 60, and by two o'clock the next day to 160. On the self-same evening a regiment on duty at Portsmouth was in a perfectly healthy state, but by the next morning so many of the soldiers of the regiment were affected by the influenza that the garrison duty could not be performed by it."

After reviewing the various hypotheses which had been put forward to account for the disease, sudden thaws, fogs, particular winds, swarms of insects, electrical conditions, ozone, Sir Thomas Watson goes on to say:—

"Another hypothesis, more fanciful perhaps at first sight than these, yet quite as easily accommodated to the known facts of the distemper, attributes it to the presence of innumerable minute substances, endowed with vegetable or with animal life, and developed in unusual abundance under specific states of the atmosphere in which they float, and by which they are carried hither and thither."

This hypothesis has certainly more facts in support of it now than it had when Sir Thomas Watson gave utterance to it in 1837; and when another epidemic of influenza occurs, we may look with some confidence to having the hypothesis either refuted or confirmed by those engaged in the systematic study of atmospheric bacteria. Among curious facts in connection with influenza, quoted by Watson, is the following:—"During the raging of one epidemic, 300 women engaged in coal dredging at Newcastle and wading all day in the sea, escaped the complaint." Reading this, the mind naturally turns to Dr. Blackley's glass slide exposed on the shore at Filey, and upon which no pollen was deposited, while eighty pollen grains were deposited on a glass at a higher elevation.

SMALL-POX

Let us next inquire into the evidence regarding the conveyence of small-pox through the air. In the supplement to the Tenth Report of the Local Government Board for 1880-81 (c. 3,290), is a report by Mr. W. H. Power on the influence of the Fulham Hospital (for small-pox) on the neighbourhood surrounding it. Mr. Power investigated the incidence of small-pox on the neighbourhood, both before and after the establishment of the hospital. He found that, in the year included between March, 1876, and March, 1877, before the establishment of the hospital, the incidence of small-pox on houses in Chelsea, Fulham, and Kensington amounted to 0·41 per cent. (*i.e.*, that one house out of every 244 was attacked by small-pox in the ordinary way), and that the area enclosed by a circle having a radius of one mile round the spot where the hospital was subsequently established (called in the report the "special area"), was, as a matter of fact, rather more free from small-pox than the rest of the disrict. After the establishment of the hospital in March, 1877, the amount of small-pox in the "special area" round the hospital very notably increased, as is shown by the Table by Mr. Power, given on p. 32.

This Table shows conclusively that the houses nearest the hospital were in the greatest danger of small-pox. It might naturally be supposed that the excessive incidence of the disease upon the houses nearest to the hospital was due to business traffic between the hospital and the dwellers in the neighbourhood, and Mr. Power admits that he started on his investigation with this belief, but with the prosecution of his work he found such a theory untenable.

Now the source of infection in cases of small-pox is often more easy to find than in cases of some other forms of infectious disease, and mainly for two reasons:—

1. That the onset of small-pox is usually sudden and striking, such as is not likely to escape observation.

2. That the so-called incubative period is very definite and regular, being just a fortnight from infection to eruption.

The old experiments of inoculation practised on our forefathers have taught us that from

ADMISSIONS OF ACUTE SMALL-POX TO FULHAM HOSPITAL, AND INCIDENCE OF SMALL-POX UPON HOUSES IN SEVERAL DIVISIONS OF THE SPECIAL AREA DURING FIVE EPIDEMIC PERIODS.

Cases of acute small-pox.	The epidemic periods since opening of hospital.	Incidence on every 100 Houses within the Special Area and its Divisions.				
		On total special area.	On small circle, 0-¼ mile.	On first ring, ¼-½ mile.	On second ring, ½-¾ mile.	On third ring, ¾-1 mile.
327	March-December, 1877	1·10	3·47	1·37	1·27	·36
714	January-September, 1878	1·80	4·62	2 55	1·84	·67
679	September, 1878-October, 1879..	1·68	4·40	2·63	1·49	·64
292	October, 1879-December, 1880 ..	·58	1·85	1·06	·30	·28
515	December, 1880-April, 1881	1·21	2·00	1·54	1·25	·61
2,527	Five periods	6·37	16·34	9·15	6·15	2·56

inoculation to the first appearance of the rash is just twelve days. Given a case of small-pox, then one has only to go carefully over the doings and movements of the patient on the days about a fortnight preceding, in order to succeed very often in finding the source of infection.

In the fortnight ending February 5th, 1881, forty-one houses were attacked by small-pox in the special mile circle round the hospital, and in this limited outbreak it was found, as previously, that the severity of incidence bore an exact inverse proportion to the distance from the hospital.

The greater part of these were attacked in the five days, January 26-30, 1881, and in seeking for the source of infection of these cases, special attention was directed to the time, about a fortnight previous, viz., January 12-17, 1881. The comings and goings of all who had been directly connected with the hospital (ambulances, visitors, patients, staff, nurses, &c.) were especially inquired into, but with an almost negative result, and Mr. Power was reluctantly forced to the conclusion that small-pox poison had been disseminated through the air.

During the period when the infection did spread, the atmospheric conditions were such as would be likely to favour the dissemination of particulate matter. Mr. Power says :—" Familiar illustration of that conveyance of particulate matter, which I am here including in the term dissemination, is seen, summer and winter, in the movements of particles forming mist and fog. The chief of these are, of course, water particles ; but these carry gently about with them, in an unaltered form, other matters that have been suspended in the atmosphere, and these other matters, during the almost absolute stillness attending the formation of dew and hoar frost, sink earthwards, and may often be recognised after their deposit. As to the capacity of fogs to this end, no Londoner needs instruction; and few persons can have failed to notice the immense distances that odours will travel on the 'air-breaths' of a still summer night. And there are reasons which require us to believe particulate matter to be more easy of suspension in an unchanged form during any remarkable calmness of atmosphere. Even quite conspicuous objects, such as cobwebs, may be held up in the air under such conditions. Probably there are few observant persons of rural habits who cannot call to mind one or another still autumn morning, when from a cloudless, though perhaps hazy, sky, they have noted, over a wide area, steady descent of countless spider-webs, many of them well-nigh perfect in all details of their construction."

A reference to the meteorological returns issued by the Registrar-General, shows that on the 12th of January, 1881, began a period of severe frost, characterised by still, sometimes foggy, weather, with occasional light airs from nearly all points of the compass. This state of affairs continued till January 18, when there was a notable snowstorm, and a gale from the E.N.E. For four days, up to and inclusive of January 8, ozone was present in more than its usual amounts. During January 9—16, it was absent. On January 17, it reappeared; and on January 18, it was abundant. Similar meteorological conditions

(calm and no ozone) were found to precede previous epidemics.

Mr. Power's report, with regard to Fulham, seems conclusive, and there is a strong impression that hospitals, other than Fulham, have served as centres of dissemination.

In the last lecture I gave you the opinion of M. Bertillon, of Paris, and quoted figures in support of that opinion. It is a fact of some importance to remember that small-pox is one of those diseases which has a peculiar odour, recognisable by the expert. As to its conveyance for long distances through the air, there are some curious facts quoted by Professor Waterhouse, of Cambridge, Massachusetts, in a letter addressed to Dr. Haygarth at the close of the last century. Professor Waterhouse states that at Boston there was a small-pox hospital on one side of a river, and opposite it, 1,500 yards away, was a dockyard, where, on a certain misty, foggy day, with light airs just moving in a direction from the hospital to the dockyard, ten men were working. Twelve days later all but two of these men were down with small-pox, and the only possible source of infection was the hospital across the river.

PHTHISIS.

There is no disease with which we are more familiar than tubercular disease of the lungs—consumption, or phthisis, as it has been called. It is a disease which has been the opprobium of medicine, and which, when well established, is rarely recovered from. The views as to the nature of the changes which take place in the lungs have been almost as varied as the writers have been numerous. And it is only within the last few years that we have arrived at anything like a fixed opinion as to the nature of the disease. This advance has been due to Koch, the eminent physician and sanitarian of Berlin, who seems to have proved that there is always to be found in association with tubercular disease a micro-organism, which he has called the *Bacillus tuberculosis*. There is no doubt about the bacillus. Koch having shown the way, we none of us have any difficulty in finding it. It is not present in those forms of lung disease which are not tubercular, but it is invariably associated with tubercle wherever found, and it is easily detected in the matter coughed up by consumptive patients.

It has long been known that tubercular disease is infective, *i.e.*, that a localised focus of the disease in any part of the body might infect the whole body, and it has been lately shown that the disease is definitely inoculable, and that the *Bacillus tuberculosis* is probably its true cause.

Is the *Bacillus tuberculosis* a fact or a fancy? The importance of settling this question cannot be over-estimated, for if it be proved that the bacillus is the actual cause of tubercular disease, that consumption is, so to say, a zymotic, our attitude towards the disease in the future will be very different from what it was in the past.

The arguments in favour of the bacillary cause of tubercle seem to me to be as strong as they can well be, and it is a noteworthy fact that the acceptance of the theory by physicians and pathologists in this country becomes daily more and more general.

I think it will be conceded also that many of the well-known facts regarding phthisis are more in accord with its being an infective than a local inflammatory disorder.

That a local tubercular deposit will infect the whole body much in the way that a foul wound will sometimes infect the whole body is well-known, and arguing by analogy, this is a strong reason in favour of phthisis being an infective disease dependent on the growth of an organism.

When once tubercular disease is established, it is not often recovered from. A man contracts phthisis, for example, from working in an ill-ventilated crowded workshop. After the disease is fully established the chance of stopping it is small, notwithstanding that he be removed from the conditions which caused his trouble. If the case were due to the chemical or mechanical foulness of the air starting inflammatory action, then the disease should stop when the cause is removed. If, on the other hand, bacilli have found a home in the lungs, they would probably continue to grow after their growth had been once started. The persistence of the disease when once it gets a hold, seems to be an argument in favour of its being caused by the growth of an infecting organism.

We are still in doubt as to whether tubercle is infectious in the ordinary sense, and cases of the disease having passed from person to person by "infection" are so rare as to leave us in doubt whether some error may not have vitiated the recorded case. On the other hand, it must be borne in mind that the onset of tuberculosis is very insidious and gradual, and is not attended with any striking phenomena like the onset of the eruptive fevers, so

that the time of onset can never be determined. And, again, the disease is so common that when tubercle makes its appearance we can never say that the individual infected by it has not been exposed to infection.

Its undoubted relationship to overcrowding and bad ventilation seems to me a very strong argument in favour of its infective nature. Phthisis causes rather more than 10 per cent. of deaths in this country, and is by far the commonest of any cause of death. In any workshop where a considerable number of artisans are working together, it is highly improbable that there are not some who are in a state to infect others; and if the cubic space be small and the ventilation bad, the risks of infection are greatly increased.

The *Bacillus tuberculosis* is one of those which readily form spores, which are to the bacillus itself very much what the seed of a plant is to a cutting. We know that seeds may be kept for very long periods without losing their power of germinating. In this the spore of the *Bacillus tuberculosis* resembles a seed. It may be dried and lie dormant for a long time, but being raised with the dust of the room, and being inhaled into the lungs, we have every reason to think that such a spore is capable of infecting the individual who is unfortunate enough to inhale it. The bacilli can be cultivated outside the body, but they require a high temperature equal to that of the blood (*i.e.*, 98° and upwards to about 103° Fahr.), so that we cannot assume that in this country there is any spontaneous growth of tubercle bacilli outside the body.

Dr. George Buchanan has shown that the death-rate from tubercular disease has sensibly decreased in certain localities, where effectual sewerage works have been carried out. Why there should be this connection between sewerage and pulmonary consumption is not clear.

The sewerage works, by removing filth from the neighbourhood of dwellings, would be likely to improve the health of the dwellers and increase their power of resisting infection.

Again, a certain amount of definitely dangerous and infective matter coughed up from diseased lungs would find its way into the sewers, and thus be carried completely away from the neighbourhood of the dwelling. The soil being made drier, and the air as a consequence of this drier also, the bacilli would be more likely to lose their vitality, although the spores would not be affected.

A putrid soil, or a putrefying cesspool, although they would not probably serve as a cultivation medium for the *Bacillus tuberculosis*, may serve to maintain their vitality and virulence.

Whatever may be the true explanation of the fact which has been pointed out by Dr. Buchanan, we shall all readily admit that tuberculosis does not stand alone as an instance of an infective disease, the deadliness of which is enhanced by filthy surroundings.

There is one fact in connection with tuberculosis which is difficult to explain by the theory of infection, and that is its undoubted hereditariness, for that it is a disease which runs in families in a remarkable way there can be no doubt. There is, it must be remembered, more than one infective disease which is communicated directly by the parent to the offspring, but that this is often the case in tuberculosis is rendered unlikely by the fact that the disease does not often show itself till some time after birth.

When dealing with Raulin's experiment, at the close of the last lecture, the experiment which showed the importance of almost infinitesimal ingredients in cultivating media, I took occasion to remark that a constitutional predisposition to this or that disease, such as scarlatina or tuberculosis, might mean that the blood and tissues contained some infinitesimal ingredient necessary for the growth of the organism which gave rise to the disease.

Again, may not the predisposition to consumption consist in the inheritance of a long narrow chest, which is the typical characteristic of a consumptive race? The coughing power, and the power of the lung to expel catarrhal products, is below par in such persons, and this is especially the case at the apex, which is the seat of election for the commencement of tubercular disease. The secretions of the lung lodging at this point would serve as a fitting nidus for the growth of the bacillus. Given a person whose family history points to a predisposition to consumption, it has always seemed to me, speaking as the medical officer of a life insurance office, that in estimating the probability of the individual suffering from consumption, the point of most importance to look to is the shape of the chest.

I have gone rather fully into some of these details, because of the general belief that phthisis is a disease inseparable from certain climates, especially climates like our own, which are cold and damp. It will appear, however, that it is rather an accident, so to say, attendant upon living in such a climate;

a climate which induces us to live in overcrowded dwellings, and to neglect the important considerations of cubic space and ventilation.

The following facts, culled from the works of Dr. Parkes and Professor de Chaumont, are not without interest.

The large death-rate in this country from diseases of the respiratory organs Professor de Chaumont believes to be due to the breathing of impure air, a cause which affects all classes of the community—high, low, rich, or poor; and he gives an interesting diagram of the death-rate from these diseases in the registration districts north of the Thames, which shows tolerably conclusively that the death-rate is proportionate to the crowding, and also to the population gathered round any particular spot. That is to say, that overcrowding under all circumstances is a cause of respiratory disease, but that overcrowding in a large town is more harmful than in a comparatively small one.

During the years 1830-46, the mean mortality from phthisis in the army on home service amounted to 7·86 per 1,000 of strength, the highest mortality being among the Foot Guards, with whom it reached 11·35 per 1,000 of strength. This state of things attracted the attention of Sir Alexander Tulloch and Dr. Balfour, who pointed out that, in the Equitable Assurance Company at that time, the average mortality between the ages of 30 and 40, from all diseases of the lungs, amounted to 3·4 per 1,000. The army mortality from phthisis was, therefore, three times greater than necessary.

The large mortality from phthisis among this picked class of the population, a class picked for its high physical qualities, and leading a life which at first sight would seem typically healthy, naturally roused inquiry as to the cause.

That it was not due to climatic conditions seemed tolerably plain, for the mortality of our troops from the same cause appeared to be equally great at some foreign stations. Thus at Gibraltar 41 per cent. of the total deaths among the troops were caused by phthisis in the years 1837-46, while in the year 1875 only 23 per cent. of the deaths were due to this cause. At Malta we are told that in former years phthisis was the cause of 39 per cent. of the deaths, or nearly the same as at Gibraltar. Latterly there have been fewer deaths at Malta. In the island of Jamaica the deaths from phthisis in the years 1817-36 amounted to 7·5 per 1,000 of strength; while in 1859-66 the mortality from this cause had fallen to 1·42 per 1,000 of strength. In Trinidad, lung disease killed on an average 11·5 per 1,000 of strength between 1817 and 1836, while the mortality from this cause has now greatly diminished.

Turning from the warm stations of the Mediterranean, and the warm equable climates of the West Indies, to the extremely severe climate of Canada, we notice, in the first instance, that Canada is reckoned to be exceptionally healthy; and further, we are told that—

"The amount of phthisis has always been smaller than in home stations, and regiments of the Guards proceeding from London to Canada have had on two occasions a marked diminution of phthisical disease. The comparatively small amount of phthisis is remarkable, as the troops have at times been very much crowded in barracks. They have now the home allowance of space (600 cubic feet)."

In the twenty years 1817-36, the deaths from phthisis were 4·22 per 1,000 of strength, whereas in 1859-65, they were but 1·67 per 1,000. This improvement in Canada has been coincident with a similar improvement at home. The reporters call attention to the fact that these Canadian returns show how little the tendency to phthisis is increased by extremes or sudden changes of temperature.

Phthisis in India, per 1,000 of Strength.

	Died.	Invalided.
Bengal—		
1863-66	1·707	2·729
1867-70	1·752	3·636
Bombay—		
1863-66	1·526	3·280
1867-70	1·238	3·576
Madras—		
1863-66	1·458	3·656
1867-70	1·336	4·737

Army at Home.—1864-70.

	Died.	Invalided.
Household Cavalry	3·763	8·234
Cavalry of Line	1·416	4·025
Foot Guards	2·300	9·491
Infantry of Line	2·120	5·510

How regularly the cause of phthisis must be acting in India is seen, says Parkes ("Practical Hygiene," p. 683), in the fact that in the four years, 1863-66, 74 men died from phthisis in the Bombay Presidency, and 73 in the Madras Presidency, the mean number of troops being in each case almost precisely the same (12,119

and 12,512.) For the next four years, with a smaller number of troops, 53 and 55 died in the two Presidencies.

The Table seems to me to show clearly that the immense range and variation of climates in which the troops serve in India have no effect whatever on the production of phthisis; and this inference is again strengthened by the fact that the mortality in Bengal from phthsis is almost precisely the same as in Canada.

A reference to the Table will show that there is less phthisis in India than at home. There can be no doubt that the causes of phthisis are less active in India; and if these causes are not climatic, must the difference not be found in the larger breathing space and greater lateral separations men have in India?

Among the causes of phthisis the most potent seems to be overcrowding in dwellings and the breathing of an impure air.

In Parkes' "Hygiene" mention is made (p. 123) of two Austrian prisons.

(*a*.) Prison in the Leopoldstadt, in Vienna, in which in the years 1843-47 there died 378 prisoners out of a total of 4,280, and of these 220, or 51·4 per 1,000, died of phthisis.

(*b*.) In the well-ventilated House of Correction, in the same city, in the years 1850-54, 43 prisoners died out of a total of 3,037, and of these 24, or 7·9 per 1,000, died of phthisis.

"The well-known fact of the great prevalence of phthisis in most of the European armies (French, Prussian, Russian, Belgian, English), can scarcely be accounted for in any other way than by supposing the vitiated atmosphere of the barrack-room to be chiefly at fault." This was the conclusion arrived at by the Sanitary Commissioners for the army. This view is strengthened by the fact that the British soldier has suffered from phthisis in the most beautiful climates, and every variety of station, *i.e.*, Gibraltar, Malta, West Indies, &c.

The deaths from phthisis in the Royal Navy averaged (3 years) 2·6 per 1,000 of strength, and the invaliding to 3·9 per 1,000. This is attributed to the foulness of the air on board ship. The degree of overcrowding met with on board ship is often excessive, and, if we are to accept the figures and statements published by Dr. Rattray in the Proceedings of the Medico-Chirurgical Society, in 1872, it is a matter for surprise that health on board ship is ever possible.

Dr. Rattray's observations (which are quoted by Parkes) were made on board H.M.S. *Bristol*, used for training cadets.

The cubic space for the crew to sleep in varied from 105 to 222 cubic feet, and that for the cadets from 242 to 506 cubic feet, and as the result of 150 analyses of the air, the carbonic acid was found to vary between 4·2 to 33·71 volumes per 1,000.

From what we have been saying, it will be gathered that much of the disease which is usually attributed to the effect of tropical climate may be avoided. If municipal, domestic, and personal hygiene demand our careful attention in temperate climates, this necessity is increased a hundredfold as we advance into the tropics. We have seen how health may be maintained in Arctic regions in spite of the necessary neglect of what in this country we have come to regard as the indispensable rules of health. When the dweller in northern climates, who has learned the art of living in spite of cold, turns towards the tropics, he is apt to forget that to live in warm latitudes requires scarcely any art at all, and he often finds to his cost that the dwellings, the clothing, and the diet with which he has comforted himself in the north are hindrances to health and comfort in the tropics. If the diet be moderated, if the clothing be adapted to the climate, if very ample cubic space be given in the houses, and, above all, if towns and dwellings be kept absolutely clean and sweet and free from every kind of decomposing filth, then we find that most of the diseases inherent to a tropical climate vanish.

Malaria.

There is one great class of diseases, however, which are practically unavoidable, and which demand our attention.

These are the various ailments which are attributed to malaria, and which include the various forms of intermittent and remittent fevers, and some forms of dysentery. Malarious diseases are due to peculiar conditions of the soil, and in order to understand the question, a few observations on "soil" in general become necessary.

We have previously alluded to the effect of soil on temperature, and to the power it has of absorbing and radiating the sun's heat.

Soils are of all degrees of porosity, between the solid rocks on the one hand, and the loose sands and gravels on the other.

There is a general opinion that dry soils are

more healthy than damp soils. Dryness or dampness of soil depend—(1) upon the amount of moisture brought to it; (2) upon the power of the soil to allow the wet to percolate; and (3) the configuration of the surface, and the provisions for drainage.

All soils contain more or less organic matter, both animal and vegetable, as must be evident if we consider the constant additions to the surface, of dead leaves and vegetable *debris*, of animal excrement and animal remains. These may be washed into the soil by rains, or may be brought to it by rivers. Soils which, to the unaided eye, seem to be composed entirely of mineral matter, contain, in reality, considerable quantities of organic matter. This is the case in sandy plains, at the mouths of great rivers, as in Holland and the Landes, and it is also the case in some rocks which are much weathered and fissured, and which allow water to soak into them.

There is always active life in soil, or the potentiality of active life under favourable circumstances. Not only are there such animals as earthworms, but even in the driest soils there are found bacteria, which only require a certain amount of moisture and heat to start them growing.

The soil of towns, especially such a town as Munich, whose sandy soil is riddled with cesspools, is often sodden with sewage, and has its pores stuffed with excremental *debris*, and often no doubt contains the germs of specific diseases, such as typhoid, cholera, or phthisis. The pores of the soil are full of air, and this air always contains a large proportion of carbonic acid, a sure sign that fermentative, putrefactive, or respiratory processes are going on in it.

The gases in the soil may be drawn into neighbouring houses by the heat of the fires, and in fact coal-gas escaping from a pipe in the street has, in this way, been drawn into a a house, with fatal results.

In like way unwholesome gases, generated by the putrefaction of an impure soil, may find their way into houses, and with the gases doubtless the micro-organisms upon which the putrefaction depends, and possibly specific micro-organisms as well.

There are many micro-organisms which only flourish under certain conditions. Not only must there be organic matter for them to prey upon, and moisture and warmth to allow of their manifesting vitality, but the access of air is also necessary. If the soil be completely permeated by water, or if it be actually dry, then many forms of bacterial life languish, but when soil water which has been high subsides, leaving the soil moist and allowing full access of air, then bacterial life reaches a maximum, and we run great risk of zymotic disease. At least, so says Pettenkofer, who asserts that at Munich epidemics of typhoid and cholera occur with the recession of the subsoil water.

Of course, as the subsoil water gets low, the surface wells draw more and more upon the neighbouring cesspools, and the state of the soil need only act indirectly through the water supply.

The close connection between subsoil water and zymotic disease has not been observed to any great extent in this country. The fact that phthisis diminishes as the soil becomes drier and less sewage-sodden, a fact pointed out by Dr. George Buchanan, has a new interest now that tubercular disease has been found to be inseparably connected with a bacillus, and we seem to be brought within sight of a possible explanation of the connection between town drainage and a diminished death-rate from phthisis.

The best and in fact the only way to purify the soil is to cultivate it, and while we ought to be most careful that the soil round our houses (and beneath them) does not get overcharged with organic matter, we ought at the same time, by judicious planting, to take care that such organic matter as there is, is turned to its right use.

With regard to the production of malaria in a soil, all writers seem to be agreed that three things are necessary, viz., sufficient organic matter in the soil to undergo a fermentative or putrefactive change, and sufficient warmth and moisture to foster the process.

If the moisture be in excess (as when a marsh during winter is submerged), malaria ceases, and if the malarious soil be completely drained and dried, malaria ceases. It would seem to be necessary for the production of malaria that water should not be present in quantity too great to allow the access of air to the interstices of the soil.

Many marshy soils contain a very large amount of organic matter; and many other kinds of malarious soils, such as sandy deltas, contain more organic matter than at first sight appears likely; and many sandy malarious districts which appear dry have in reality a layer of water not far below the surface. In spite of facts which appeared at one time

adverse to such a conclusion, the opinion is now generally held that for the production of malaria we must have a soil containing organic matter apt for decay and putrefaction, and a certain amount of warmth and moisture. These are the conditions essential for that bacterial growth upon which putrefactive, fermentative, and similar disorganising processes depend. What is the nature of this malarial poison? In the first place, it may be carried by air or by water; secondly, it may be carried considerable distances, and may be wafted along a valley, up a ravine, or across a plain in the direction of the wind. This fact makes it unlikely that the poison can be a gas, for the law of diffusion and dispersion would soon render any gas practically harmless. Again, the behaviour of the poison, and the history and symptoms of malarious disease, make it unlikely that the poison is gaseous, for our knowledge of gaseous poisons almost forbids us to believe that any gas could give rise to exacerbations and remissions lasting for months, or even years. There are certain other facts, such as the power of a belt of trees to filter the poison out of the air, and the difficulty which it apparently has of rising far above the level of the ground in still weather, which make it likely that the poison is particulate. Krebs and Crudeli assert that they have discovered the malarial poison in the form of a bacillus, the *Bacillus malariæ*, which is found in the soil of the Roman Campagna. Although we can hardly believe that the poison can be anything but a microbe of some kind, the observations of these two savants, nevertheless, need confirmation.

Malaria is sometimes developed in other ways. The first turning up of a rich virgin soil is always a dangerous process in the tropics, and is very apt to be followed by an outbreak of malarious disease. It would seem as though the free admission of air to the interstices of the soil had the effect of starting that form of life on which malaria depends. Decaying vegetable matter, on a comparatively small scale, has occasionally given rise to malaria, and instances are recorded of the generation of malarious fevers from heaps of indigo-plants being allowed to rot and decompose, and from heaps of decaying vegetables. Malarious fevers have also broken out on board ship from similar causes. Given the conditions of soil which give rise to malaria, its virulence seems to increase with increase of temperature.

The only way of combating malaria seems to be the drainage and cultivation of the soil. The more productive the land can be made the less are the risks of malaria. In England malarious troubles have become rare, but if from any cause the land should go "out of cultivation," the political economist will have to take malaria into consideration in dealing with the results.

The cultivation of the land seems always to do good. The planting of the eucalyptus has been productive of good results in some places, and, at Sierra Leone, the growing of grass in the streets has been beneficial. In the course of centuries, possibly, many of the most deadly of the tropical foci of malaria may be subdued by the husbandman, but practically we have to regard malaria, at the present as an unavoidable evil inherent to certain localities.

Occasionally malaria will develop in a place which has been previously healthy. This occurred in the Island of Mauritius, some sixteen years ago, and a glance at the Table showing the health of our troops in foreign stations at two different periods, will give some idea of the effect of this scourge on the British soldier.

The Mauritian fever seems to have been caused by the clearing of forests, the upturning of virgin soil, the increased defilement of the ground by increase of population, and the constant draining down of both animal and vegetable filth into a loose soil of slight depth. Then, in 1866, came deficient rainfall with a fall in the subsoil water, and the free admission of air to the interstices of the soil. The conditions being given, malaria broke out and still continues. Before 1866 there was no malarious disease in the island. Since then it has raged more or less continuously, and when the fever was at its height in 1867, quinine fetched as much as £40 per oz.

Mountain Climates.

A few words may be said as to the peculiarities of mountain climates, but this need not detain us long, since what has been previously said will have enabled us to anticipate what these peculiarities are. We will take as an example, that district which is just now much visited by the British tourist and the British traveller, and which is doubtless well known to many here present—I mean Davos and the Engadin, in the canton of Grisons Switzerland.

The health resorts in this district are between 5,000 and 6,000 feet above sea level. The barometer stands at about 25 inches instead of the average 30, which means that the atmosphere exerts a pressure of 12½ lbs. on each square inch of the body instead of 15 lbs., which is the normal at sea-level. As a consequence of this the blood-vessels of the skin dilate, and the inhabitants are singularly ruddy and healthy-looking. It is from the same cause, probably, that the capacity of the thorax increases, and the dwellers in this region are, as a rule, full-chested.

The weight of the oxygen in a given volume of air is less than in the plains, and to this, as well as to the diminution of pressure, is due the fact that the new-comer to this district feels short of breath, and the action of the heart and the respiration are both quickened at first. The body soon accommodates itself to altered circumstances, and in a few days the shortness of breath disappears, and pulse and respiration fall to their normal rate. The temperature of the air is less than in the plains, the fall in temperature as we ascend being, on an average, about 1° Fahr. for each 300 feet.

The moisture in the air is slight, both absolutely and relatively, and the drying power of the air considerable. In consequence of the rarefaction of the air, and the slight amount of moisture, the sun's rays penetrate it easily, and have a remarkable power of heating solid bodies exposed to them. Thus the temperature in the sun may be scorching, while the shade temperature is freezing, or far below freezing. The power of the sun's rays is often increased in these regions by being reflected off rocks and snow, so that it often happens, in the depth of winter, that even invalids can saunter in the sunshine without discomfort or danger. The middle of the day is hot, but before and after sunset the cold is very great. The cold at night, however, is often not so great on the hill-side as it is in the valley; for the cold air, chilled by the icy mountain top, falls, by gravitation, to the lowest point, and settles in the valley.

The alterations of temperature are sudden, and the effect of the sun on the thin mobile atmosphere of these mountain districts is remarkable. There are few sights more astonishing or more beautiful than to see the sun rise in these districts, or to see him make his first appearance after a period of cloudy, rainy weather. The sombre valley, choked with woolly clouds, is cleared almost in an instant by the first ray of sunshine that falls into it. Solid masses of cloud are apparently licked up by the darting sunbeams, and peak and crag, glacier and tranquil lake, verdant alps, and picturesque chalets on the instant stand out clear and distinct, while the observer is as suddenly swathed in genial warmth, and is soon made to forget the cold and discomfort which characterise these regions when the sun forgets to shine.

The amount of rainfall and wind varies in accordance with aspect and local considerations.

At great elevations there is a good chance of getting a pure air to breathe. If a town or village be perched on a mountain side, the filth and impurity will obey the laws of gravity, and flow away down the mountains to annoy those who live below, instead of breeding sickness at the spot where the filth is formed. It is, doubtless, the purity of the air which constitutes one of the most valuable elements of mountain climates.

The effects of these climates are seen in an increase of animal spirits, increase of appetite, increase of energy and power of muscular exertion. To enjoy a climate of this kind a fairly good constitution is necessary, and some power of taking physical exercise and withstanding cold.

A word of caution seems necessary, and it is this, that directly a health resort becomes the fashion it is within measurable distance of ruin. Density of population brings with it its attendant evils, difficulties of water supply and drainage, accumulations of filth, and an atmosphere stuffed with microbes. The authorities at these places cannot be too careful to prevent the close packing of houses and the erection of barrack-like hotels without adequate curtilage.

For healthy tourists, who are constantly on the move, and who are out of doors all day, and who are strong enough to tolerate fresh air even in their bedrooms, the question of hotels is, after all, a minor matter. But to send a consumptive patient to spend twenty or twenty-two hours out of every twenty-four hours during the winter in a barrack filled with consumptives like himself, is a proceeding which is more likely to do harm than good. The one thing a consumptive patient needs more than anything else is fresh air to breathe. An overcrowded hotel which smells of drains, dinners, and humanity, is not an ideal spot in which the consumptive should seek health.

The facts which I have brought before you must lead to the conclusion that a large proportion of the disease which is loosely attributed to "climate" is, in reality, due to a wanton neglect of sanitary rules.

Sanitary rules with regard to ventilation, cubic space, and the disposal of filth, rules which we find it so necessary to observe even in a temperature like ours, demand far more scrupulous observance in the tropics. The majority of diseases which are fatal to us in the tropics are in fact filth diseases, and, with the exception of malaria, there can be no doubt that much of the sickness and mortality of tropical countries is distinctly avoidable.

In order to give point to this assertion, I cannot do better than call attention to the West Coast of Africa, a district with a most evil reputation as regards health.

It will be profitable to glance at the causes of mortality in this dreaded region, and ascertain to what extent that mortality is inevitable. Sierra Leone has at present a population of about 37,000, and a garrison of some 500 black troops. There are mangrove swamps north and south of the town. The water supply is good. From 1817 to 1837 the mortality among the whole white population was about 17 per cent., and among the troops the army returns show that there were annually 2,978 admissions to hospital, and 483 deaths per 1,000 of strength. It thus appears that the military death-rate at that period was not far from being three times as great as the civil death-rate.

If we turn to the causes of this terrible sickness and mortality among the troops, we find that malaria was a great cause of sickness, but not a great cause of death, and that yellow fever and dysenteric disease were among the most fatal complaints. Yellow fever is an acute infective disease, which occurs especially in climates where the temperature ranges above 70° F., although it may drag on a languishing existence even in temperate climates like this. Recent researches show that yellow fever is not in any way connected with malaria, but that it is a tropical filth disease, and that the great causes of its localisation are (according to Parkes) overcrowding and the accumulation of excremental matters round buildings:—

"And here we find the explanation of its localisation in the West Indian Barracks in the olden times. Round every barracks there were cesspits, often open to sun and air. Grant that yellow fever was somehow or other introduced, and let us assume (which is highly probable) that the vomited and fæcal matters spread the disease, and it is evident why, in St. James's Barracks, at Trinidad, and St. Ann's Barracks, at Barbadoes, men were dying by dozens, while at a little distance there was no disease."

Again, with regard to dysentery, we find the opinion very strongly expressed that its chief causes are impure water and impure air, brought about by overcrowding and fæcal emanation. To these causes must be added injudicious feeding and drinking. The errors of diet which seem to predispose to dysentery are, mainly, the taking of food in an early stage of decomposition, and a diet of imperfect construction, and such as leads to a scorbutic habit. The dysentery which was so fatal to the troops on the West Coast of Africa, was, we are told, chiefly scorbutic.

"The causes of this great mortality were simple enough. The station was looked upon as a place of punishment, and disorderly men, men sentenced for crimes, or whom it was wished to get rid of, were drafted to Sierra Leone. They were very much overcrowded in barracks, which were placed in the lower part of the town. They were fed largely on salt meat, and being, for the most part, men of desperate character, and without hope, they were highly intemperate, and led in all ways lives of utmost disorder. They considered themselves, in fact, under sentence of death, and did their best to rapidly carry out the sentence."

So frightful was the mortality on this dreaded West Coast, that the white troops were ultimately replaced by black troops from the West Indies, and it is estimated that the total white population of Sierra Leone, of late years, has not exceeded 200.

From what has been said, it is evident that much of the sickness on this coast is preventable, and, indeed, of late years the health of Europeans at this station has been much improved.

The housing and feeding of the troops has undergone marked improvement, and the growing of Bahama grass in the streets and round the houses is supposed to have ameliorated some of the climatic conditions.

In the four years, 1863-66, we are told that eight non-commissioned officers (white) died on the West Coast, and of these eight, three died of liver disease, two from *delirium tremens*, two from fevers, and one from dysentery. It would be difficult to say which of

these eight died from unavoidable climatic conditions.

Among the black troops serving at Sierra Leone and the adjacent stations, phthisis and lung diseases appear to be the most fatal disorders.

In the ten years, 1861-70, the deaths were 22·49 per 1,000 of strength, and of these phthisis caused 7·05 per 1,000 of strength. In some years the deaths from phthisis were in greater proportion.

In 1862, phthisis, killed 12·6 per 1,000, and pneumonia 9·46 per 1,000. In 1863, phthisis killed 9·3 per 1,000, and in 1867 tubercular disease killed per 1,000 of strength—17·71 in Sierra Leone; 15·87 at the Gambia; 12·58 at the Gold Coast and Lagos. In 1862, we are told, there were only 5 cases of intermittent and 18 of remittent fever (23 cases of malarious disease) among 317 negroes.

At Gambia, as at Sierra Leone, phthisis and lung diseases were the chief causes of death among the black troops, and the reason for this is to be found, probably, in the ill-construction and bad ventilation of the barracks. Speaking of the West Coast generally, Dr. Parkes says :—

"There is no doubt that attention to hygienic rules will do much to lessen the sickness and mortality of this dreaded climate. In fact, here, as elsewhere, men have been contented to lay their own misdeeds to the climate. Malaria has, of course, to be met by the constant use of quinine."

The other rules are summed up in the following quotation from Dr. Robert Clarke, who is a most competent judge of the climate of this coast :—

"Good health may generally be enjoyed by judicious attention to a few simple rules. In the foremost rank should be put temperance, with regular and industrious habits. European residents are too often satisfied with wearing apparel suited to the climate, while they overlook the fact that exercise in the open air is as necessary for health here as elsewhere. Many of them likewise entertain an impression that the sun's rays are hurtful, whereas, in nine cases out of ten, the mischief is done, not by the sun's rays, but by personal habits.

"Feeling sadly the wearisome sameness of life on this part of the coast, recourse is too frequently had to stimulants, instead of resorting to inexhausting employments, the only safe and effective remedy against an evil fraught with such lamentable consequences. Europeans also bestow too little attention on ventilation, far more harm being done by close and impure air during the evening and night than is ever brought about by exposure to the night air. Much of the suffering is occasioned by over feeding."

Nothing can show more conclusively the value of the labours of sanitarians both at home and abroad than the subjoined Table showing the sickness and mortality of British troops per 1,000 of strength, on home and foreign stations, and for two periods, in 1861 and the decade, 1871-80.

It will be observed that the mortality has been lessened at all stations save two—the Cape and Mauritius. The increased mortality of the Cape is accounted for by the Zulu campaigns, and that of the Mauritius by the appearance of malaria in the island :—

Health of British Troops at Home and Abroad.

Per 1,000 of strength.

	1861.*		1871 to 1880.†	
	Annual admissions to hospital.	Mortality.	Annual admissions to hospital.	Mortality.
India	1,768	37	1,454·3	19·37
China	1,492	28	1,196·3	13·8
Ceylon	1,440	20	971·3	15·26
Bermuda	461	14	632·7	8·72
West Indies	1,002	13·5	913·6	11·02
Cape & St. Helena	950	11·0	899·2	39·96‡
Mauritius	608	12	1,834·7	17·13
Malta	772	11	857·1	9·77
Canada	644	8·2	667·9	6·64
Gibraltar	927	9·0	675·9	6·67
United Kingdom	1,025	9	817·5	7·95
On board ship	...	...	571·5	7·64

The facts which we have been considering in these three lectures and the reflections which we have made will, I hope, prevent us from being hasty in condemning the climate of any country or locality as "unhealthy." Healthiness and unhealthiness are to a great extent in our own keeping all the world over. "The pestilence which stalketh in darkness" does so mainly because our eyes are shut, and we have long been in the habit of blaspheming

* Army Medical Report, quoted by Dr. Aitken ("Science and Practice of Medicine," second edition).

† Army Medical Report, 1881.

‡ Campaign.

the unseen powers for "sending" us diseases which are clearly of home manufacture. Ignorance and filthiness have in times past turned many an earthly paradise into a plague spot. Let us hope that the dawn of better things is at hand, and that when those who plume themselves on being the enlightened sons of civilisation take possession of some island of the tropics, the lines of Bishop Heber may be in no ways applicable, in which he tells us that—

> "Every prospect pleases,
> And only man is vile."

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